Par **Lita Sari BARUS**

Contribution to the intercity modal choice considering the intracity transport systems : application of an adapted mixed multinomial Logit model for the Jakarta-Bandung corridor

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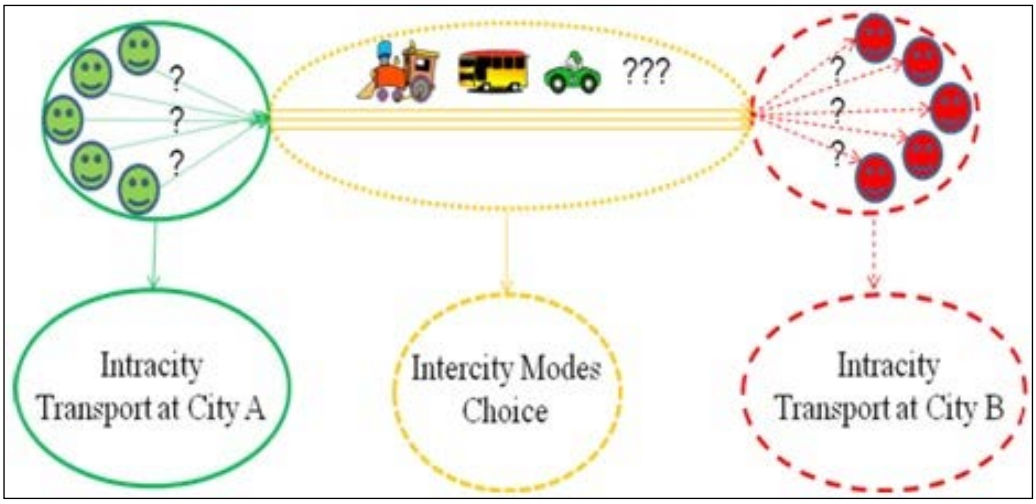

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Contribution to the Intercity Modal Choice considering the Intracity Transport Systems: Application of an Adapted Mixed Multinomial Logit Model for the Jakarta-Bandung Corridor

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PREFACE

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Lita Sari Barus

ABSTRACT

Name : **Lita Sari Barus**

Research Program : **Urban Systems**

Title : **Contribution to the Intercity Modal Choice considering the Intracity Transport Systems: Application of an Adapted Mixed Multinomial Logit Model for the Jakarta-Bandung Corridor**

An ideal city or intercity transport system is one where all the transport networks, involving in general different modes of transport, could serve together the cities connections to fulfill a passenger demand and satisfaction. Each transport network should have a logical layout (as possible with minimum discontinuities) to meet the required demands. Also in that ideal system, the different modes of transport should not only have their own good performances but also the exchange between modes should be done with harmony. The conditions as mentioned above are worldwide challenges. The present work deals with the transportation problematic between two Indonesian cities, and also with the high modal competition on the Jakarta-Bandung corridor. On that corridor, road transport is currently the main demanding mode for passengers transportation. The airlines cannot compete and discontinued their operations to this route. Nowadays, railway transport is decaying.

Passengers preferences are the main variables for the final modal choice. It is necessary to know preferences due to their decisions impacts to choose one mode over the others. Those preferences are in fact not simple to express in a complex city and intercity transport system. In transportation, the Logit model is widely used as a method to explore the problematic of modal choices involving a lot of different variables. There are several Logit models already developed, such as “General

Extreme Value", "Probit", and "Nested model", but in this research, they are not compatible to solve our defined problems because there are some particular identified variables to be taken into account. Therefore we propose the "Adapted Mixed Multinomial Logit (AMML)" Model as a tool for analysis towards passenger's decision in modal choices.

On the Jakarta-Bandung corridor, modal choices are influenced by the encountered problems in intercity transport at origin and destination. One part on this research deals with identification and understanding of the intracity transport problems of origin and destination on the choice of transport mode in Jakarta-Bandung corridor (Jakarta-Bandung and Bandung-Jakarta direction). The second part of this research deals with the final decision process by analyzing the results of questionnaires addressed to many users of the Jakarta-Bandung corridor. The five main variables of the last questionnaire are travel time, overall cost, security conditions, quality of travel information and connectivity conditions relevant to intercity transport and intracities transport conditions as well. After validation of the questionaires, this research uses the AMML model to get final decision result by comparing one mode among three intercity transport mode (train, minibus, and car) using the values of the variables. Taking into account the characteristics of each intercity mode of transportation, the analysis identifies the most competitive intercity transport mode for each situation from departure city to arrival city. Using alternative public and private transport modes policies, one could in the future modify passenger choice on intercity transport mode. Therefore, this study is relevant for improving of intracity and intercity transport systems.

Keyword: Intracity and Intercity Transport Systems, Modal Competition, Modal choice, Passengers' Preferences, "Adapted Mixed Multinomial Logit (AMML)" Model

RÉSUMÉ

Nom/prénom : **BARUS Lita Sari**

Recherche programme : **Génie des Systèmes Urbains**

Titre : **Contribution au choix modal interurbain en considérant les systèmes de transport intra-urbains: Application d'un modèle LOGIT mixte multinomial adapté au corridor Jakarta-Bandung**

Un système idéal de transport inter cités et intra cité est celui dont tous les réseaux de transport, comprenant en général différents modes de transport, permet de donner satisfaction aux demandes des passagers. Chaque réseau de transport doit avoir une structure logique (la moins discontinue possible) pour répondre aux exigences requises. Dans un système idéal, les différents modes de transport ne doivent pas seulement se préoccuper de leurs bonnes performances propres, mais aussi d'échanger de manière harmonieuse avec les autres modes de transport. Les conditions citées précédemment restent un défi dans le monde entier. Ce travail de recherche traite de la problématique des transports dans les villes d'Indonésie, Jakarta et Bandung, mais également de la grande concurrence modale du trajet Jakarta-Bandung et Bandung-Jakarta. Sur ces trajets, le transport routier est actuellement le principal mode de transport emprunté. Les compagnies aériennes n'etaint pas à la hauteur de la concurrence ne sont plus en service. Il convient d'ajouter à cela le fait que de nos jours, le transport ferroviaire est en déclin.

Les préférences des passagers sont des variables très importantes à connaitre en raison de leurs impacts pour choisir un mode de transport parmi d'autres. Ces préférences ne sont pas simples à exprimer dans un système de transport intra cités et inter cité complexe. Dans les transports, le modèle Logit est largement utilisé comme une méthode pour aborder la problématique du choix de transport multimodal comportant de multiples variables. Il existe plusieurs modèles Logit déjà développés, tel que «General Extreme Value», «Probit», et «Nested». Mais dans la présente

recherche, ces modèles ne sont pas appropriés pour la résolution de nos problèmes, car il y a des variables particulières à identifier et à prendre en compte. Par conséquent, nous avons développé pour nos besoins le modèle «Logit Mixed Multinomial Adapté (LMMA)» comme outil dédié à l'analyse décisionnelle dans le choix des modes de transport des passagers.

Sur le trajet Jakarta-Bandung (et Bandung-Jakarta), le choix du mode de transport est influencé par les problèmes rencontrés dans les transports intra cité d'origine et de destination. La première partie de nos travaux de recherches porte sur l'identification et la compréhension des problèmes de transports intra cité d'origine et de destination pour le choix du mode de transport entre Jakarta et Bandung (et puis entre Bandung et Jakarta). La seconde partie concerne le processus de décision final en proposant et en analysant les résultats d'un questionnaire adressé à de nombreux utilisateurs de la liaison Jakarta-Bandung (et Bandung-Jakarta). Les cinq principales variables du dernier questionnaire sont le temps de voyage total, le coût global, les conditions de sécurité physique, la qualité des informations disponibles et celle des lieux de connections. Ces cinq variables concernent aussi bien les transports intra cité (origine et destination) que le transport inter-cité. Après validation des modelés, les résultats d'aide à la décision sont obtenus en utilisant le modèle MMLA : chaque mode de transport inter-cité (train, minibus, voiture) est comparé aux deux autres modes à l'aide des valeurs des variables. L'analyse permet pour chaque situation d'origine et de destination, et en tenant compte des services offerts par chaque mode inter-cité, d'identifier quel est le mode le plus compétitif. Par la voie de politiques de transport publiques et privées on pourrait apporter des modifications aux valeurs des variables et ainsi modifier le choix d'un mode de transport inter-cité (ou le rendre plus compétitif par rapport aux autres). Nos travaux constituent ainsi une proposition importante pour l'amélioration des systèmes de transport intra cité et inter cité.

Mot-clé: Systèmes de Transport Inter cité and Intra cité, Concurrence Modale, Choix Modal, Préférences des Passagers, Modèle «Logit Mixte Multinomial Adapté (LMMA)»

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CHAPTER I INTRODUCTION

1.1 Research Background

The transportation activities between the big cities with short distances, such as Jakarta – Bandung, could cause the density of traffic on their inter-city transport network. Modes of transport, such as road transport, planes and trains, are some choices of user to travel with. One has to choose a mode over the others. This can lead to competition between modes.

The design of the transport network in an area can be as subsystems connected to other subsystems, overall and integrated in a macro transport system. Relations between these subsystems are as a result of the need for inter-subsystem (Tamin, 2000). Furthermore, the connectivity between transportation in the city with transportation between cities forms a transport system macro (global).

Intensive interconnection between two big cities with short distances can generate the high traffic. Increasing the types and number of transport modes in the same corridor raises competition in the competitive intermodal passenger numbers (Ming et al, 2010). Each passenger will use one type of mode that can provide maximum service to meet the needs of passengers. Some studies have suggested the need for a flexible transit services. This is to overcome the problems of sub-urbanization and dispersed travel patterns (Koffman, 2004).

Competition between modes can occur in conditions of increased service, and then change the passenger choice. Consequently types of modes that are not selected will be the mode of losing the number of passengers. In this case, these type modes can not survive in this competition. Transportation services needed include affordability, meet

the required capacity, decent travel time, flexible or reliability of modes to meet the needs of passengers (Vedagiri and Arasan, 2009)

Before the 20th century, the railway is growing rapidly in many countries, but subsequently decreased mainly due to the construction of roads and improvement of air transport services (Brons et al, 2009; Ayidin and Dzhaleva-Chonkova, 2013). Railway investment needs to be maintained because it is an environmentally friendly mode of transport and can improve the economy of a city. This transport can also reduce the level of congestion. Although some researchers said the existence of negative effects, including the noise around the railways and in station (Grimes and Young, 2013).

Passengers have some criteria to travel according to their characteristics, the destination and purpose of the trip. If an inter-city transport mode does not meet their requirements then they will choose the other. On the other hand, if the transport mode does not have a sufficient number of passengers, then its operating costs will be very expensive. In the long term, this condition will be very inefficient because of transportation services can not be storage (Yu and Lin, 2008). Types of modes that cannot compete in the competition means it can be concluded inadequate to operate.

Transport modelling is used to analyze how the passengers make their decisions to modal choice. This modelling can be evaluated numerically solutions through a mathematical formula. In certain conditions, several models and studies have been built to address the problems of alternative modes of transport. The selection process of one mode to the others can be estimated by maximizing the utility offered from any mode (McFadden in the 1970s in the Ming et al, 2010).

Some researchers have tried to establish some approaches to know intermodal service gaps. The quality improvements of transport services for inter-city transport modes

need the support of the quality services of intracity transport. This condition is in the context of a total transport chain from origin to final destination.

Currently, the discussion of this topic is developed constantly to advanced levels of some models of travel demand. Logit models is the model most often used in transport planning, because this model has the ability to perform complex modelling travel behaviour by simple mathematical techniques. Mathematical framework of a logit model is based on maximizing the utility theory (Ben-Akiva and Lerman 1985). Logit models are generally classified into two main categories, namely Binary and Multinomial logit models. Binary logit models can perform modelling only two choices and Multinomial logit models can be done in more than two options. In a complex transport system, it is possible for more than two choices; therefore, this study explores the Multinomial Logit Model.

Multinomial logit models are affected by the utility function. The change of utility value will change the mode of choice opportunities. The probability is expressed in the probability function of Multinomial Logit Model. Logit models in the form of a mathematical model are a classical statistical formula. In its development, logit model was adapted with some extra consideration. Fisher has developed into a logit Mix (Fisher, 1950). Furthermore, McFadden and Train have been adapted into a Mixed Multinomial Logit Model (McFadden and Train, 2000).

This research has been conducted on the formulation of a model to determine the effect of the characteristics of the transport service in the city in determining the choice of inter-city transport mode. The model was developed in discrete behaviour to solve problems of inter-city transportation mode choice that affected by the transport system in the city. The model has been applied to the Jakarta-Bandung corridor.

1.2 Problems Statement and Research Questions

On a complex transportation system, modal choice between cities has become a complex problem. Considerations of the passengers to choose the type of mode are not only on the condition of the inter-city mode, but also the conditions of transport in the city of origin and destination. In the big cities as the city of origin of the passengers were in various zones, as well as at the final destination. In the city of origin and destination, there are many public transportation possibilities that can be selected for user from the area of origin to inter-city transport modes. There are alternatives that can be either single or multi-modal transport. Complex transport conditions are a challenge for multi-modal transport in competing with a single transport. These complex situations are the problems in analyzing the characteristics of inter-city transport mode choice.

Those problems led to the following research questions:

1. How can the characteristics of the users of intercity transport choose one intercity transport mode over the others between the two major cities?
2. How to build a model of mode choice that considers the travelling from origin to the final destination?
3. How does the improvement of a mode of transport can be done by using the characteristics of the user's choice mode based on the level of service of various types of mode choice?

This analysis is important in order to solve existing problems in realizing the sustainability of all the available transport modes in the integration of the intracity and intercity transport system.

1.3 Research Aim

The research aims to obtain a formulation of inter-city passenger movement by considering alternative modes of transportation on the network in the city. The development of this model deals to the choice of modes on the network between cities, especially big cities which are nearby. Results of the research are to obtain information about the characteristics of users in determining the mode of choice. In this case study, the focus is directed at the development of the railway service corridors Jakarta-Bandung.

In the future, this approach could serve as a model in evaluating the improvement of services and find the limits of customer satisfaction oriented. Increased services will be able to increase the opportunity of a mode to be chosen over the others.

1.4 Novelty, Scientific and Pragmatic Contributions

Development of the classical approach Multinomial Logit Model is done for modal choice problems in the integrated network of intracity and intercity transport which is applied to the Jakarta-Bandung corridor. Model "Adapted Mixed Multinomial Logit (AMML)" has been built to address these issues with a more precise calculation.

Pragmatic contributions are as follows:

1. Identification of transport services that contribute significantly to the inter-city transport mode choice in modal competition, especially in the corridors Jakarta-Bandung
2. Indicating the influence of transport services, in particular intracity transport systems to the modal choice of intercity mode.

Development model from the classical Multinomial Logit Model is necessary for the integration links of intracity and intercity transport problems which could be applied on the Jakarta-Bandung corridor. To deal with this problem "Adapted Mixed Multinomial Logit (AMML)" Model can be used for the precise results.

1.5 Research Outline

This dissertation is organized as follows:

Chapter I Introduction

This chapter deals with description of the research background, problem statement and research questions, research aim and significance of the research, novelty, scientific and pragmatic contributions, and research outline.

Chapter II Literature Study

This chapter discusses about transportation system, intercity transport system, intracity transport system, passengers and modes characteristics, service variables of modal choice, modal choices model, in high modal competition, transport policies in Indonesia, and conclusion.

Chapter III Research Methodology

This part explained research framework, survey method, questionnaires survey results, model development, validation model, and model limitations are presented.

Chapter IV The "AMML Model" Application

This chapter presents research design, intercity transport between Jakarta and Bandung, the economic affordability analysis, of intercity transport modes, evolution of ideas about the modal competition, analysis data on the corridor Jakarta-Bandung, modal competition of corridor, and transportation characteristics.

Chapter V Conclusion and Perspectives

Finally, this part will resume this research with some conclusions. It contains some topic about the consideration of intracity transport system in intercity mode choices, model development, improving mode's competitiveness, and model simulation. Further analysis to the next researches was expressed on the perspectives.

CHAPTER II LITERATURE STUDY

2.1 Transportation System

Transportation is a travelling of passengers or a movement of goods from one place to another (Morlok, 1978). Bowersox (1981) has stated that the movement of goods or travelling of passengers from one location to another because of the need to arrive in certain location. This is a cause of product-driven. A sequence of transport modes which are used to carry a certain quantity of goods from its origin to its destination is called transport chain. In this chain it could need one or more transshipment (Kristiansen, 2007). Travelling in a corridor could be associated with socioeconomic and geographic activities. Geographical movements could be the movement between one area to another within the city (intracity transport system) and also to other city (inter-city transport system). The intracity transport system and intercity transport system are subsystems in the global transport system (Figure 2.1.).

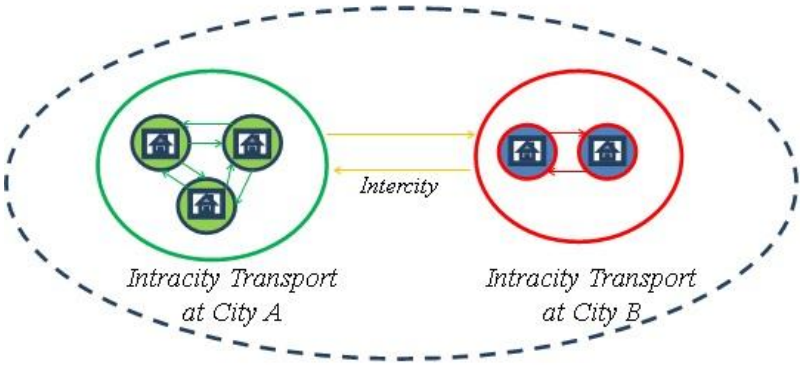


Figure 2.1. Global Transport System

2.1.1 Intercity Transport System

Inter-city transport mode serves passenger in traveling from one node to another between cities. The demand between cities can be forecasted with a model (compiled

by Manheim and Marvin 1979). Furthermore, the transport demand, by Kanafani (1983), is analogous to the scheduled economic activities or a function of customer demand to transport goods and services. These activities require time and energy as a measure of performance of the transport system. Needs of this movement requires a certain mode which has several criteria, such as the condition of the user, the difference in income, time and cost.

In this research, it was found that passengers could not travel on one link. In their total transport chain, it could be more than one link. The first link is a link with the travelling between the origins to the modal node in the departure city. The second link is the travelling between modal nodes at departure city to another modal node at arrival city. The third link is the travelling between modal node at arrival city to the final destination. Thus the study of inter-city transport has become a complex system (Fig. 2.2).

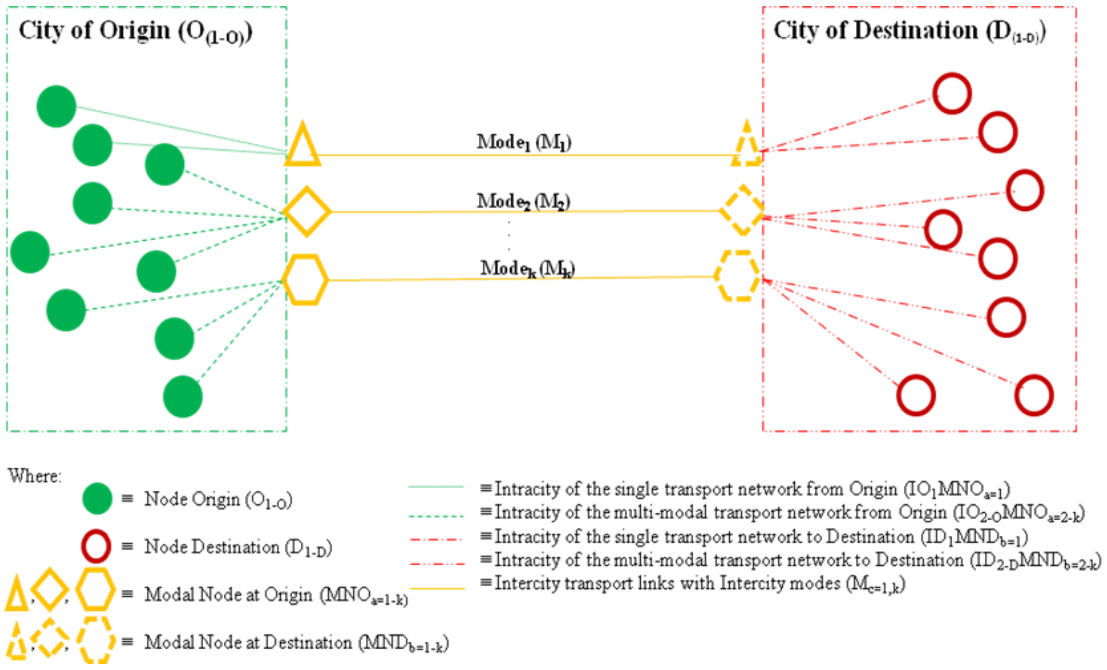


Figure 2.2. The Complexity of Intercity Transport System from Origin to Destination

In this case, travelling in inter-city transport link is not the main purpose. Inter-city transport passengers have to face intracity transport problems to achieve their main purpose. Therefore, inter-city transport link is influenced by several other links which have different conditions of transport characteristics. The integration of the components into intermodal is very important to realize a continuous travelling of passengers, from "door to door" (Givoni and Rietveld, 2007).

Differences of transportation characteristics can be identified from the difference in the level of service that provided by each type of modes on each link. Service levels can be measured from the characteristic mode as variables. In the first link, the service level is affected by the variable of intracity transport system. The second link is influenced by service variables of the intercity transport mode. And the third link is influenced by several variables of intracity transport system at the destination city.

Interaction between the two cities is supported by the intracity and inter-city transports. These activities can use a single transport mode or multi-modal transport. Some terms that used by some researchers for the needed to use more than one mode of transport, such as a multi-modal, combined transport, intermodal transport and co-modality (Reis et al., 2013). Multi-modal transport implies that there is a need to use more than one mode on a particular link or a certain corridor. Intermodal transport indicating at least the existence of two different transport modes involved in the total transport chain "door to door" for a trip of passenger transport. The service conditions given by a single transport mode or multi-modal transport is influenced by the characteristic mode of transportation.

2.1.2 Intracity Transport System

The transportation system in the city (transport system micro) is an activity within the city that have a relationship between one and the other, for example, traveling to work, school, center of sport activities and others from a particular place that is integrated in the system of land use (Tamin, 2000). From one land use system to another, the traveler uses the transport network system. The traffic flow is allowing workers to go to work, students to go to school, and so on. In transportation planning, traffic movement is designed to be easy and efficient, but in the reality, it could be different.

Transportation modes designed to provide convenience and efficient, but there is a problem of accessibility. Accessibility is a concept that combines land use regulation system to be achieved through the transport network system (Black in Tamin, 2000). Accessibility is the ability to measure the level of convenience to get to the destination of the road network system. Accessibility can be a variable distance, travel time, quality of service, or cost.

The formulation of accessibility within the city is a combination of several zones (N) and all activities (A) in the central zone. Accessibility (K) for one zone is an intensity of each activity in each zone in the city and access to reach the center zone of the transport network system. The physical size for accessibility is as (Hansen, 1959 in Suhardi B., 2004):

$$K_i = \sum_{d=1}^{N} \frac{Ad}{tid} \quad \text{.....(2.1)}$$

Where:
K_i ≡ accessibility zone i to other zone (d)
A_d ≡ Activity at zone d (such as number of jobs, etc)
t_{id} ≡ time and cost from zone i to zone d

Furthermore, the size of accessibility is developed with a systematic component of maximum utility symbolized in logit models as V * (a measure of accessibility), where Cn is a set of options, for the multinomial logit model. Accessibility is a measure of the size scale of the efforts of several alternative trips. Generally, this measure is a special measure individually. This measure takes into account the expected utility value associated with a set of options as (Ben-Akiva and Lerman, 1985):

$$V^*_n = \frac{1}{\mu} \ln \sum_{i \in Cn} e^{Uin} \quad \text{.....(2.2)}$$

Where:
V^*_n ≡ measure of accessibility
U_{in} ≡ utility value mode i

Users of multimodal transport require centre of transfer/transit. Transit system is a system of transfers that use private transport to public transport or public transport to public transport. Transit performance can be identified from a combination of operating costs and service quality. In certain situations, there are the unfavorable conditions for passengers, for example, the amount of time to wait, the time duration of a trip by car or by walking activities (Chandra et al, 2011).

The transit system which did not connect directly from door to door, then it requires the feeder transit service performance. Many transit feeder services with operations following the pattern of the user's needs. Usually they adapt to the situation of residential areas (Koffman, 2004; Potts et al., 2010). Their performance depends on several factors such as the ability of the driver, stop frequency, the type of bus stops, and the number of passengers at each stop. Furthermore, a major factor in the performance of the feeder depending on the condition of the road network and connectedness with the activities required (Chandra, 2013).

Another study (Prasertsubpakij and Nitivattananon, 2012) of the Metro System in Bangkok Metro System concluded that the perception of discomfort associated with lack of accessibility, and safety of the surrounding environmental conditions. It would be better if there is a balance access to services. This is accounted for in the model of accessibility disaggregate transport users.

2.2 Passengers and Modes Characteristics

2.2.1 Passengers Characteristics

Passengers, who are traveling on intercity transport, depend on the availability of private transport mode and public transport mode on the link. They will consider every possible trip with all available existing modes. Passengers' travel proposes are to do some activities, for example to go to work, to study, to do sport, etc. According to "Passengers Preferences", the necessities of transport mode might be changed. If there are several transport modes are available, then they will choose the most advantage one (Tamin, 2000).

Any choice is, by definition, made from a nonempty set of alternatives. The environment of the decision maker determines what we shall call be the *universal set* of alternatives. Any single decision maker considers a subset of this universal set, terms *a choice set*. The feasibility of an alternative is defined by a variety of constrains (Ben-Akiva and Lerman, 1985). The selection process is done by calculating the maximum value of total variables. Selected mode should be has a maximum value of the potential benefits over the other (McFadden 1970s in Ming et al, 2010).

Passengers' decision process is different from travel's steps. Their decision process depends on their way of thinking. It is begun with the consideration of transport

condition at departure city because they know the conditions better than other transport conditions. Next process is the consideration of transportation condition at arrival city because they want to do their activities at that place. And then passengers will consider which intercity transport mode could support them. Finally, they will choose "the package" which gives the maximum advantage in all process (Fig. 2.3).

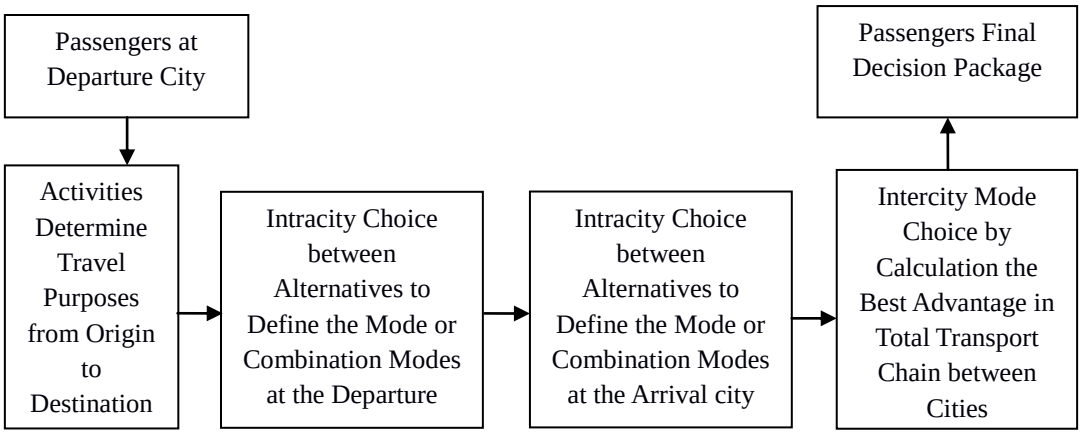


Figure 2.3 Passengers Decision Process in Choosing "The Package of Transport Mode" in Total Transport Chain

The package of transport mode could be single transport mode or multimodal transport. Usually private transport is the single transport mode, for example car and public transport is multimodal transport, for example minibus and train. Each passenger who chooses single or multimodal transport has to face the condition as follows:

1. Public transport mode 1 (for example train) passengers

The intracity transport condition could affect passenger's choice before they use the train. It is a lot of uncertainties in the departure and arrival cities. The uncertainty is a risk to passengers. The uncertainty could reduce the interest of the passengers in using train over the other modes. But if passengers have arrived at the rail station, then the possibility to switch to other mode is very small, so they will continue their journey by

train. Thus the possibility to change to other mode when they have arrived at the rail station can be ignored (0).

2. Public transport mode 2 (for example minibus) passengers

Although the minibus uses the toll road network as well as private car, but they are considered in different network due to the different starting and end point of their trips. Before and after intercity travelling, passengers could use one mode or some combination modes from their home and to their final destination. Transport conditions in intracity transport could affect the passenger intercity mode choices. If they have arrived at minibus pole, then they continue to the next pole by minibus. The possibility to switch to other modes is very small and in the mathematical models this possibility is ignored (0).

3. Private transport passengers

When car passengers have arrived at the first highway toll gate, then they continue their journey to the next highway toll gate by car. The intracity transport condition does not allow them to change to other modes, because the intracity transport condition is very complex, so to move to other mode will cause a lot of "costs". This is a normal condition, although in reality there are some passengers that can switch their mode. That condition is ignored (0).

2.2.2 Modes Characteristics

Mode transport characteristic depends on its type, such as private or public mode (Table 2.1). Nowadays, using private mode is more popular. The implication of this is congestion and pollution. This situation could not attract a large number of car users to switch to public transport (Henser, 1998). Policies could increase public transport usage by promoting its image, but it is not enough. It should become more market-oriented and competitive. It means that it has to improve public transport service

quality, which can only be achieved by a clear understanding of travel behavior and consumer needs and expectation (Beirao, 2007).

Table 2.1 Perceived Advantages and Disadvantages of Public Transport and Private Car

No	Advantages	No	Disadvantages
A	Public Transport		
1	Cost	1	Waste of time
2	Less stress	2	Too crowded
3	No need to drive	3	Lack of comfort
4	Be able to relax	4	Time uncertainty
5	Be able to rest or read	5	Lack of control
6	Travel time on public transport schedule	6	Unreliability
7	Less pollution	7	Long waiting times
8	Talk to other person on the vehicle	8	Need to transfers
		9	Traffic
		10	Lack of flexibility
		11	Long walking time
B	Private Car		
1	Freedom/independence	1	Cost
2	Ability to go where I want	2	Difficulty of parking
3	Convenience	3	Cost of parking
4	Rapidity	4	Stress of driving
5	Comfort	5	Traffic
6	Flexibility	6	Waste of time in rush-hour traffic
7	Know what I can expect	7	Pollution
8	Safety	8	Accidents
9	Having my own private space	9	Isolation
10	Listen to music		

Source: Gabriela Beirao, J.A. Sarsfield Cabral, 2007

However, understanding travel behavior is not easy. For each journey, passengers have their own specified travel behavior. Each journey needs a certain mode of transport and might be different in another journey. The choice of one specific transport mode could be vary over time and type of journey. They could use private and public transportation in their journey from one place to the other. To make people switch

totally to use public transport is a question of service quality. To get the best service quality, each mode has to consider each variables constraints over the others.

2.3 Services Variables of Modal Choice

Users, operator, and government, as the stakeholders, have their own variables to consider for one mode over the others. They optimize their variables to all available alternatives to get the maximum advantage value of their utility and choose the alternative with the highest value, but their interests are not the same (Lyons and Harman, 2002).

Variables considered by users are as follows

- access time, characterized by deterministic variations (business/leisure, residents/visitors), combined-mode choice, transfer location choice, route choice
- other variables, such as: departure time from home, arrival time at destination, departure time from destination, arrival time at home, tour travel time, duration of stay at destination, travel cost not including (extra) peak charge, peak charge (second experiment only, probability of a seat (public transport mode only), and frequency (public transport mode only). Reliable and offered at a suitable cost will able to maximize convenience through travel opportunities (including consideration of their life style changes, trust of the available information).

Variables considered by operator such as:

- traffic volumes, network capacity, distribution of car traffic among different time periods during the day
- values of travel savings for access, line haul, egress trip legs, waiting times
- effect of fare competition on company profitability, overall network congestion.

- traffic volumes, network capacity, distribution of car traffic among different time periods during the day.
- the bottom line return on investment
- travelling time and lower operational costs per available seat kilometer.
- The primary market segment

Variables considered by government policy such as:

- inter-mixing of jobs-housing function
- an outline of the current form of the public transport (focus on bus and rail services) looking at the complex responsibilities and relationships which entails.
- the main national initiatives for integrated traveler information provision
- regulatory controls over routes, time table, fares (deregulation) and sale of publicly owned companies
- a better environment (reduced pollution), more efficient use of resources in all transport system, more sustainable quality of life for everyone.

The importance of quality variables was discussed by some researchers and also the research about accessibility evaluation of feeder transit services.

2.4. Modal Choices Model

The global transport system becomes more complex in function of its demand and of the number of available modes and alternatives as the road network extension. A wrong decision of a passenger in making a choice in the total travel would cause a high cost or important extra delay. In the previous studies, computational technology has led to the development of procedures to select the most appropriate travelling mode. The quantification of travel attributes which influences certain individual in mode choosing can be mathematically represented by modal choice model.

Modal choice as a behaviour model is defined as a representation of decision that made by consumers when confronted with alternative choices. This choice is made on the basis of the term upon which the different travel modes are offered, for example the travel times, costs, and other level-of-service attributes of the competing alternative travelling modes. The shift from single modal toward multimodal system could be done by improving the three performance indicator, such as cost efficiency, service effectiveness, and cost effectiveness (Yu and Lin, 2008).

The models that tend to represent the travel behaviour of the individuals when provided with a discrete set of travelling alternatives are commonly known as discrete choice models. The method of transport mode division is a selection model by an individual which is based in maximization of utility (McFadden 1970s in Ming et al, 2010). The utility of a travelling mode is defined as an attraction associated to an individual for a specific trip. Therefore, the individual is visualized to select the mode which has the maximum attraction, due to various attributes. This hypothesis is known as utility maximization and all the travel demand models are based on this theory. An essential transport demand analysis was the development of disaggregate travel demand model base on discrete choice analysis methods. At the disaggregate travel demand, it could observe that the behaviour of an individual as a decision maker in choosing mode over the other.

The discrete choice model was continued, developed with an adaptation on random utility theory (McFadden 1974 in Hensher and Rose, 2007). Random variables were considered utility of modes alternatives in counting probability to choose and from time to time it was expanded (Hensher and Rose, 2007). One mode cannot directly take place of other mode, because of the differences in mode's characteristic and services. Passengers need to decide which one will give the maximum advantage to them. The method to choose one mode over the other is known as modal choice

model. Logit model is the previous and most popular method. Mathematical framework of logit models is based on the theory of utility maximization. Logit models are generally classified into two main categories namely binomial if there are two choices and multinomial if there are more than two. The model is continuously developed with some specific definition, such as (McFadden, 1981; Ben-Akiva and Lerman, 1985):

1. Logit Model with:
    - Extreme value distribution
    - Error term is the Identically Independent Distribution (IID)
2. Probit Model with:
    - Normal distribution
    - Error not the Identically Independent Distribution (IID)
3. GEV Model with:
    - Multivariate extreme value distribution
    - Error not the Identically Independent Distribution (IID)
4. Nested Model with:
    - A structure which has partitions of the alternatives into groups (nests)
    - The choices should be dependent to be one group
    - If all modes are independently choice, than they can not consider as a partition into a group.

2.4.1 Utility Function

All logit models are specified on the basis of utility function and are applied according to the probability of an individual by selecting out a mode over the other. Utility value of each mode can be found by analyzing the travellers' satisfaction. The values of variables are considered to have a strong relationship with the behaviour of the

traveller's satisfaction. Utility is defined as a maximized value by every individual. It contains a random selection function. The random function will give an idea about the value of the selection function $V_{(i)}$ or values of attributes have different effects on different individuals or by the same individual at different times. This statement is called random utility model and expressed as a vector notation of the utility function (Ben-Akiva, 1985):

$$U_{in} = V_{in} + \varepsilon_{in} \quad \text{.....(2.3)}$$

Where:
U_{in} ≡ Utility value for the alternative (i) in individuals (n).
V_{in} ≡ Random variable of alternative (i) was observed (systematic) in individuals (n)
ε_{in} ≡ alternative stochastic component (i) in individuals (n)

It was developed (Bliemer and Rose, 2005 in Hensher and Rose, 2007) with the observed component of utility further consists of a vector of attribute levels x_{in} as follows:

$$U_{in} = V_{in}(x_{in} \mid \beta_i) + \varepsilon_{in} \quad \text{.....(2.4)}$$

Model development above is the basic principle of selection which shows that individual will choose alternative (n), if the utility function U (n) of the alternative (n) provide the greatest value among the other utility function U (n). Furthermore, to find out the similarities V_{in} and the influences in their functions:

$$V_{in} = V(X_{in}) \quad \text{..... (2.5)}$$

To find out the various elements that affect the X, and estimate the unknown parameters, a linear function of the parameters is used. This function is denoted as follows:

$\beta = [\beta_1, \beta_2, ..., \beta_k]$ as a vector k is not known, then:

$V_{in} = \beta_1 X_{in1} + \beta_2 X_{in2} + \beta_3 X_{in3} + \ldots + \beta_k X_{ink}$ ..... (2.6)

$\beta_1, \beta_2, \beta_3, ..., \beta_k$ are treated as random variables distributed in the population. Linearity in the parameters is not equivalent to linearity in the attributes.

This previous model has been adapted by some researchers. It is adapted to be an exploratory Multinomial Logit Analysis with the case of single-vehicle motorcycle accident severity (Shankar and Manner, 1996). This exploratory method was focused in motorcycle accident severity which analyzes all influencing factors. There are five levels of severity considerations, for example: property damage only, possible injury, evident injury, disabling injury, and fatality. A multivariate model of motorcycle-rider severity considers about environmental factors, roadway conditions, vehicle characteristics, and rider attributes.

A utility function by this research is identified as follows (Shankar and Manner, 1996):

$S_{in} = \beta_i X_n + \varepsilon_{in}$ .....(2.7)

Where:

S_{in} ≡ utility value (with different symbol)

Xn ≡ a vector of measurable characteristics that determine the severity (for example rider age, rider gender, roadway attributes, prevailing weather conditions, vehicle type, usage of helmets, and so on)

β_i ≡ a vector of estimable coefficients

ε_{in} ≡ an error term that accounts for unobserved factors influencing accident severity

$\beta_i X_n$ in this equation is the observable component of severity determination because the vector X_n contains measurable variables (for example roadway attribute at the location of accident n) and in is the unobserved portion.

Other theoretical development of utility function is using heteroscedastic control for random coefficients and error components in mixed logit. It identifies preference heterogeneity and focuses on the formulation which depends on the selection of random parameters. The objective of this research is to capture additional parameters which are specifically unobserved. This research uses utility function as follows (Greene and Hensher, 2007):

$U_{qjt} = \beta' X_{qjt} + \varepsilon_{qjt}$ ..... (2.8)

Their special equation that have been developed for the constant value to be a linear equation as follows:

$\beta_{qk} = \bar{\beta}_k + \delta'_k Z_q + \Upsilon_{q,k} \upsilon_{qk}, \quad k = 1, \ldots, K,$ ……..…….....(2.9)

Where $\boldsymbol{\upsilon}_{q,k}$is a random variable with $E[\boldsymbol{\upsilon}_{q,k}] = 0$ and Var $[\boldsymbol{\upsilon}_{q,k}] = a^2_{k,}$ a known constant and $\Upsilon_{q,k} = \sigma_k$ x exp[ŋ'$_k h_q$]

Hence, the development can be done by using linear regression method with special coefficient features attained via parameterization in exponential, logistic, and multinomial logit forms. This research contained types of multiple linear regressions for prediction. The objective of this development is to get the range of coefficients in an assigned, the logistic parameterization is used which is able to avoid multicollinearity effect.

This research uses linear regression formula as follows (Lipovetsky, 2009):

$$y_i = a_1 x_{i1} + \cdots + a_n x_{in} + \varepsilon_i \equiv \hat{y}_i + \varepsilon_i, \quad \text{.....(2.10)}$$

The model suggested nonlinear parameterization of regression coefficients. If all non-negative coefficients are sought, they can be presented in the exponential parameterization:

$$a_j = \exp(\gamma_j), \quad \text{.....(2.11)}$$

Where: γ_j are the estimated parameters. To obtain the coefficients of regression between a_{min} to a_{max}, a logistic parameterization can be applied:

$$a_j = a_{min} + (a_{max} - a_{min}/1 + \exp(-\gamma_j)) \quad \text{.....(2.12)}$$

For $a_{min} = 0$ and $a_{max} = 1$, each coefficient of regression would belong to the [0,1] interval. The multinomial-logit parameterization:

$$a_j = \exp(\gamma_j)/\exp(\gamma_1) + \exp(\gamma_2) + \ldots + \exp(\gamma_n), \qquad \gamma_1 = 0 \quad \text{.....(2.13)}$$

Other previous study applied in the case of airport choice in multi-airport regions (Hess and Polak, 2005). This is the analysis of the behaviour of air travellers to choose airports. The sensitive variable is access time which characterized by deterministic variations (business/leisure, residents/visitors).

2.4.2 Probability Function

A. Probability in Multinomial Logit Model

Probability function in Multinomial Logit Model as a mode choice model is based on utility function of all modes. The "Multinomial Logit Model" built with the mathematical equations as follows (Ben-Akiva, 1985):

$$P_{n\,(i)} = \frac{e^{V_{in}}}{\Sigma_{j \in Cn}\, e^{V_{jn}}} \qquad \begin{array}{l} 0 \le P_n\,(i) \le 1, \text{ for all } i \in C_n \\ \text{and} \\ \Sigma P_n\,(i) = 1 \end{array} \qquad \text{..... (2.14)}$$

Where:

$P_{n\,(i)}$ ≡ Probability of individuals (n) to alternative (i)
e ≡ exponential
j ≡ the number of options
V_{in} ≡ Random utility of alternative (i) was observed (systematic) in individuals (n)
V_{jn} ≡ Random utility of alternative (j) was observed (systematic) in individuals (n)
C_n ≡ number of choices on the individual (n) is constrained because of their background,

Where $C_n \in C$ and C is the set of alternatives that exist in the universe (universal set)

This model uses several assumptions:

a. Random component of utility (ε_{in}) is an independently and identically distribution (IID) with a Gumbel distribution. Independent means when the factor is not observed, it does not affect existing utilities.
b. The response of the individual against the alternative attribute is homogeneous, so that the unobserved characteristics of individuals are not sensitive to attributes of alternatives.

c. Variation of covariance and error of the alternatives are identical among individuals.

This previous modal choice has been applied in real modal choice condition in some countries in as seen in several researches. In fact, due to some differences in the situation of each country and also some difference in the certain aspect, it is necessary to develop in more detail to suit to the problem in the field.

Approach for models of this type, which is assumed as ε_{in}'s with generalized extreme value (GEV) distribution and using estimated standard maximum likelihood methods is developed by. The GEV assumption produces the simple multinomial logit model (McFadden, 1981):

$$P_n(i)=\exp[\beta_i X_n]/\sum \exp[\beta_I X_n] \quad \text{.....(2.15)}$$

All variables are as previously defined. And the vector β_i is estimated by standard maximum likelihood methods.

B. Probability in Nested Logit Model

Other previous study about competitive multi-modal transit services with some groups in the choice alternative was run with a nested logit approach. The model used combined-mode choices of travellers, and the strategic interactions between the private service operators (Lo et al., 2004). Method of analysis was the nested logit (NL) approach with a three-level NL choice model, such as:

- Combined-mode choice
- Transfer location choice
- Route choice

Utility function is modified by the effect of fare competition on company profitability as well as on overall network congestion. The equation is (Lo et al., 2004):

$$\Psi_{at} = \Phi_o^{isg} + \Phi_1^{-} C_{at} \quad \text{.....(2.16)}$$

Where Φ_o^{isg} is a penalty term for each transfer from state *s* to state *g* at location *i*, Φ_1 is the coefficient for transfer waiting time and c_a, is the waiting time of the transfer link. The more transfers a route has, the more penalty terms it will incur:

$$\Psi a^{ij}_{dn} = e[\max_{k \in K^{ij}_{bs}} \pi^{ij}_k] = \frac{1}{\theta} \ln \sum_{k \in K^{ij}_{bs}} \exp(\theta \pi^{ij}_k) \quad \forall\, a^{ij}_{dsn} \text{ s.t. } \eta(s) = b_3 \quad \text{.....(2.17)}$$

Where θ is the coefficient of perception variation, and π^{ij}_k is the utility associated with route k, expressed in a form similar to:

$$\pi^{ij}_k = y_{b3} + y_1 * t^{ij}_k + y_2 * \rho^{ij}_k \forall i,j \in U_{b3} \quad \text{.....(2.18)}$$

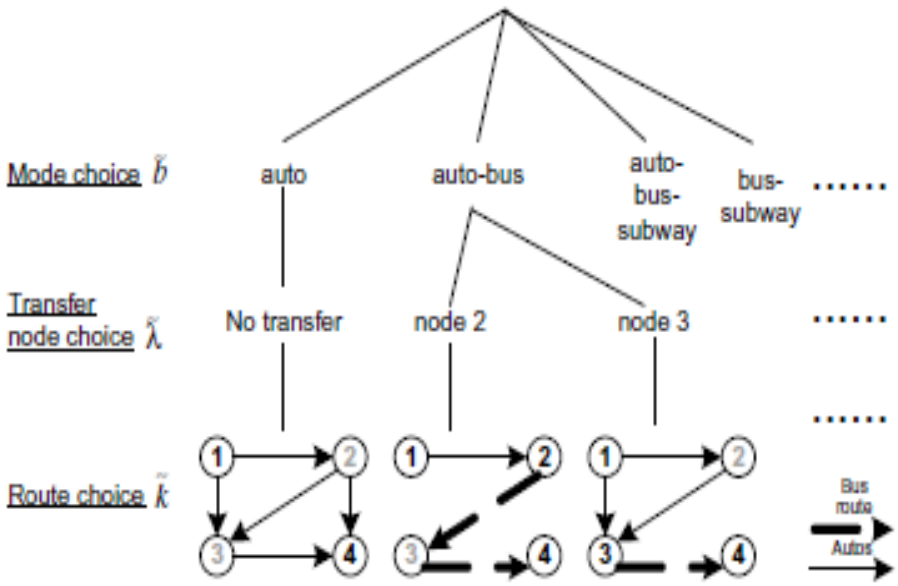


Figure 2.4. An Illustration of the Three-Level Nested Logit Structure

Where $y_{b3}$is a mode-specific constant; t_k^{ij} is the travel time on route k; ρ_k^{ij} is the monetary cost associated with route k, which can be specific to the particular mode in Class 3- as taxi charge or gasoline cost etc. Fig. 2.4 explains an illustration of the three level nested logit structures:

$$P_{\bar{k}\,|\bar{b}\bar{\lambda}}^{\overline{rs}} = \frac{\exp(\theta\pi_{\bar{k}}^{\overline{rs}})}{\sum_{\bar{k}'}\in K_{b3}^{\overline{rs}}\ \exp(\theta\pi_{\bar{k}'}^{\overline{rs}})} \quad \text{.....(2.19)}$$

C. Probability in Mixed Multinomial Logit Model

A mixed model is a statistical model containing both fixed effects and random effects. It introduced random effect models to study the correlations of trait values between relatives. Mixed modelling has become a major area of statistical research, including work on computation of maximum likelihood estimates, non-linear mixed effect models, and missing data in mixed effects models (McFadden and Train, 2000).

A mixed model presented the equation as follows (Fisher, 1950s):

$$y = X\beta + Zu + \epsilon \quad \text{.....… (2.20)}$$

Where:

y ≡ a vector of observations, with mean $E(y) = X\beta$

β ≡ a vector of fixed effects

u ≡ a vector of random effects with mean $E(u) = 0$ and variance-covariance matrix $\mathrm{var}(u) = G$

ϵ ≡ a vector of IID random error terms with mean $E(\epsilon) = 0$ and variance $\mathrm{var}(\epsilon) = R$

X and Z ≡ matrices of regression relating the observations y to β and u, respectively

Other previous transport modelling finds some considerable policies in order to observe the travel behaviour. The Mixed Multinomial Logit (MMNL) model (McFadden and Train, 2000) offers significant advantages over the MNL model by

allowing for random taste variation across decision makers. Their advantage acknowledges the differences across agents in their sensitivities to factor such as fare and frequency. The random-coefficients formulation of the MMNL model uses integration of the MNL choice probabilities over the assumed distribution of the taste coefficient, such that the probability of individual *n* choosing alternative *i* is (McFadden and Train, 2000):

$$P_{ni} = \int_{\beta} (e^{v(\beta,Xni)} / \sum_{j=1}^{I} e^{v(\beta,Xnj)}) f(\beta \mid \theta) d\beta \quad \text{.....(2.21)}$$

Where:

P_{ni} ≡ the vector of observations, with continue function

X_{ni} ≡ the vector of explanatory variables for alternative *i* as faced by decision maker *n*

β ≡ the vector of taste coefficients, In the MMNL model, the vector β is distributed randomly across decision makers, with density f(β|Θ),

Θ ≡ a vector of parameters to be estimated that represent, for example, the mean and the variance of preferences in the population.

$V(\beta,X_{ni})$ ≡ the observed utility of alternative *i*

2.4.3 Estimator Method

Generally, there are two model estimation techniques namely the maximum likelihood and least squares method. They used to estimate the discrete modal choice models, in order to calculate the values of the unknown coefficients. The method of maximum likelihood is the most common procedure used for determining the estimators in logit model. The maximum likelihood estimators are the values of the parameters for which the observed sample is most likely to have occurred. The method requires a sample of individual modal choice decision-makers along with the data regarding the travelling mode chosen and the attributes of that particular mode. The basic formulation of the method, that involves the maximization of the likelihood function as (Ben-Akiva and Lerman 1985):

$$\prod_{n=1}^{N} P_n(i)^{yin} P_n(j)^{yjn}$$

$L^* (\beta_1,\beta_2, \ldots,\beta_k) =$ …….....(2.22)

Where:

L	≡	the likelihood the model assigns to the vector of available alternatives
N	≡	the total number of available alternatives
$(j)^{yjn}$	≡	any alternative present in the set of available alternatives
$(i)^{yin}$	≡	the mode observed to be chosen
$P_n(i)^{yin}P_n(j)^{yjn}$	≡	the probability for choosing alternative

The most widely used approach is to maximize the logarithm of L rather than L itself. It does not change the values of the parameter estimates since the logarithmic function is strictly monotonically increasing. Thus, the likelihood function is transformed to a log-likelihood function as follows:

$$L^* (\beta_1,\beta_2, \ldots,\beta_k) = \sum_{n=1}^{N} \{y_{in}\log P_n(i) + (1- y_{in})\log[1-P_n(i)]\} \quad \text{.....(2.23)}$$

Other estimator method is least square. The least square estimators are the values that minimize the sum of squared differences between the observed values and expected observation values. The coefficients of regression are estimated by the basic objective function F which is given by:

$$F = \min \Sigma E^2 = \min \Sigma (\beta 0 +\beta_1 X_{ij1} + \beta_2 X_{ij2} + \beta_3 X_{ij3} + \ldots + \beta_k X_{ijk} - Y)^2 \text{……...…...(2.24)}$$

The desired coefficients are estimated using (k+1) derivatives of equation and solving for (k+1) unknowns. This method is usually called the Ordinary Least-Square (OLS). Generally, the least square estimators are unbiased under general assumptions. However, it should be noted that the least-square method work consistently and efficiently for linear models only, and can surmise erroneous coefficient's value in case of complex model specification. This present research uses the method of maximum likelihood.

2.4.4 Test of Model and Hypothesis

There are several statistical tests for the model that would be accepted. Measurement of the level of compliance data (Goodness of Fit), such as:

A. Likelihood-Ratio Value Index (rho-squared = ρ^2)

Value of the log likelihood function is the evaluation of parameter values that we expect in the equation. The calculation of log likelihood values uses the assumption that the errors are normally distributed. The size of the suitability of the data stated in the likelihood ratio index = $\rho 2$ (0) and likelihood ratio = ρ 2 (c) and is defined as (Ben-Akiva and Lerman 1985):

$$\rho^2(0) = 1 - \frac{L(\beta)}{L(0)} \quad \text{..... (2.25)}$$

and

$$\rho^2(c) = 1 - \frac{L(\beta)}{L(c)} \quad \text{..... (2.26)}$$

where:

L (β) ≡ The likelihood (L) maximum value, where the log likelihood value at convergence is reached

L (0) ≡ Initial likelihood, if all parameters = 0

L (c) ≡ Initial likelihood or the probability Pn where the value of the option is simply used to estimate the log likelihood that has the same probability of selection of alternative options with market share or proportion of these alternatives in the overall sample.

Value of ρ^2 is ranged between 0 and 1. The smaller of the likelihood ratio value (L) will increasingly significant or large difference in the value of L (β) with L (c) or L (0). This shows the spread of the analyzed data. An index likelihood ratio ρ^2 interval between 0.15 and 0.2 indicates the relevance of the data (Hu et al., 2006).

B. Chi-squared value (χ^2)

Chi-square test is a test of the accuracy of the model and used to test the null hypothesis (H_0), that all coefficients of the variables X_i (explanatory variables / independent) of the regression model is equal to zero, but does not involve constant. The alternate hypothesis (H_a) is that the coefficient of variable X_i is not equal to zero. Chi-square value can be formulated as follows (Ben-Akiva and Lerman 1985):

χestimated = -2 {L (0) - L (β)} ..... (2.27)

where:

L (β) ≡ value of maximum likelihood, where the log likelihood value at convergence is reached

L (0) ≡ likelihood at the parameter value = 0

Hypothesis: H_0: $\beta_1 = \beta_2 = \beta_i = 0$ ...

Ha: $\beta_1 \neq \beta_2 \neq \beta_i \neq 0$ ...

Testing criteria:

H_0 is rejected, if χ^2 estimated > χ^2 table

H_0 is accepted, if χ^2 estimated ≤ χ^2 table

If H_0 is accepted, it means that the resulting model can not be used to evaluate the value of the dependent variable, otherwise if H_0 is rejected, then the resulting model can be used to evaluate the value of the dependent variable.

C. Significance Tests

Significance test aims to determine the coefficients obtained from the estimation results can be accepted as the population regression parameter estimator. In general,

significance tests are able to test the hypothesis of individual coefficients of each independent variable. This test uses the test statistic t with the following formula (Ben-Akiva and Lerman 1985):

$$t = \frac{b-\beta}{S_b} \quad \text{.....(2.28)}$$

Where:
S_b ≡ standard error coefficient
b ≡ coefficient obtained
β ≡ Coefficient of the estimated population

T tests used to test the null hypothesis (H_0), that each coefficient equal to zero and the alternative hypothesis (H_a) is that if each coefficient of the model is not equal to zero.

Hypothesis: H_0: $\beta j = 0$

Ha: $\beta j \neq 0$

Criteria for testing: H_0 is rejected if the $t_{count} > t_{\alpha / 2, nk-1}$

H_0 is accepted if the $t_{count} \leq t_{\alpha / 2, n-k-1}$

CHAPTER III RESEARCH METHODOLOGY

3.1. Research Framework

Jakarta-Bandung corridor has several alternative modes of transportation including types of modes of road, railway mode and air transportation. Railway mode has several changes in performance as a result of changes in the road transport services and air transport. This research started with literature study about railway services in Indonesia, and evaluated the performance of rail service as one mode of transportation in Jakarta-Bandung corridor (Fig. 3.1).

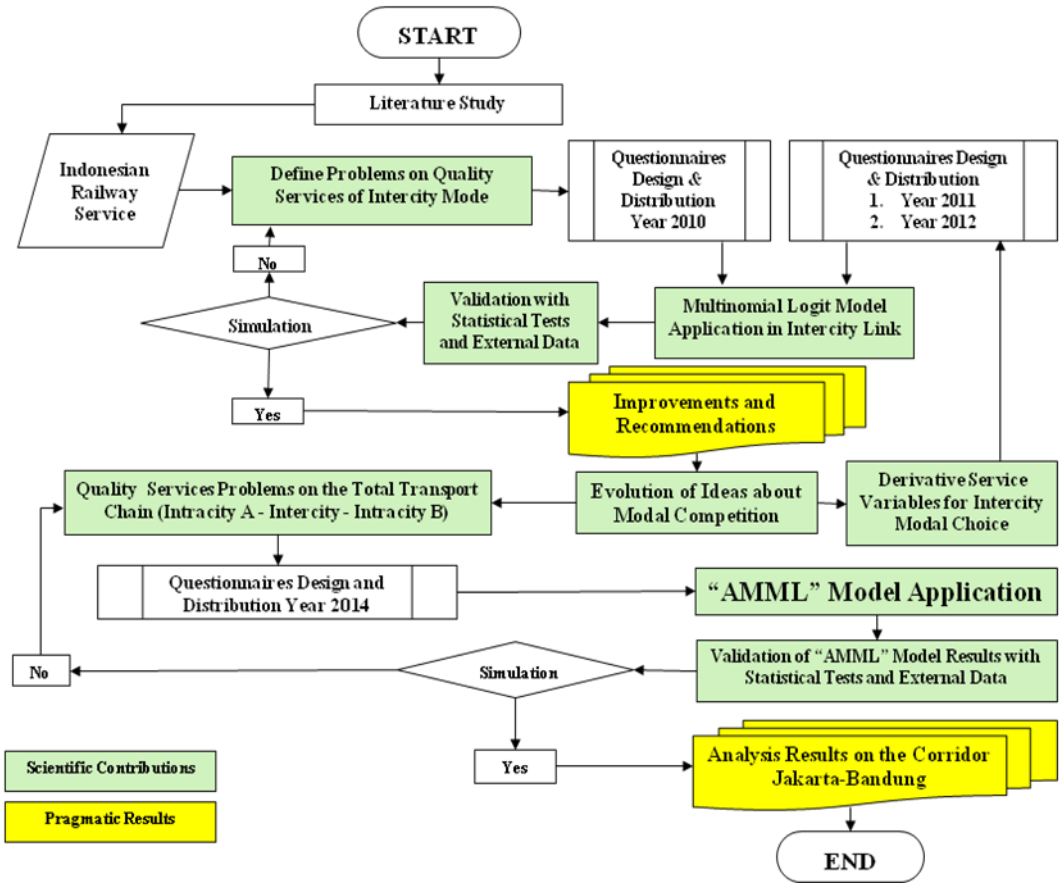


Figure 3.1 Research Activity Flowchart

Train services depending on the services of other transport modes, this dependency occurred before and after using the railway mode (Givoni and Rietveld, 2007). As a mode of intercity transportation, train very effectively

connecting one city to another. In the intercity network, where there are several types of intercity transportation mode, the railway experienced competition between modes of transport.

Inter-city transportation characteristics are influenced by the conditions of transport at departure and arrival cities (Black, 1981). Intercity passenger can be served by a single mode of transport from one node to another node on the network transport on a trip in the city of departure. Similarly, a trip to the destination, in the city of final destination of passengers was served by transport mode from zone to another zone. This study concerned three types of modes of transport such as private cars, minibuses of travel and rail. The movement of passengers from the beginning zone to the end zone as indicated by the schematic in Figure 3.2.

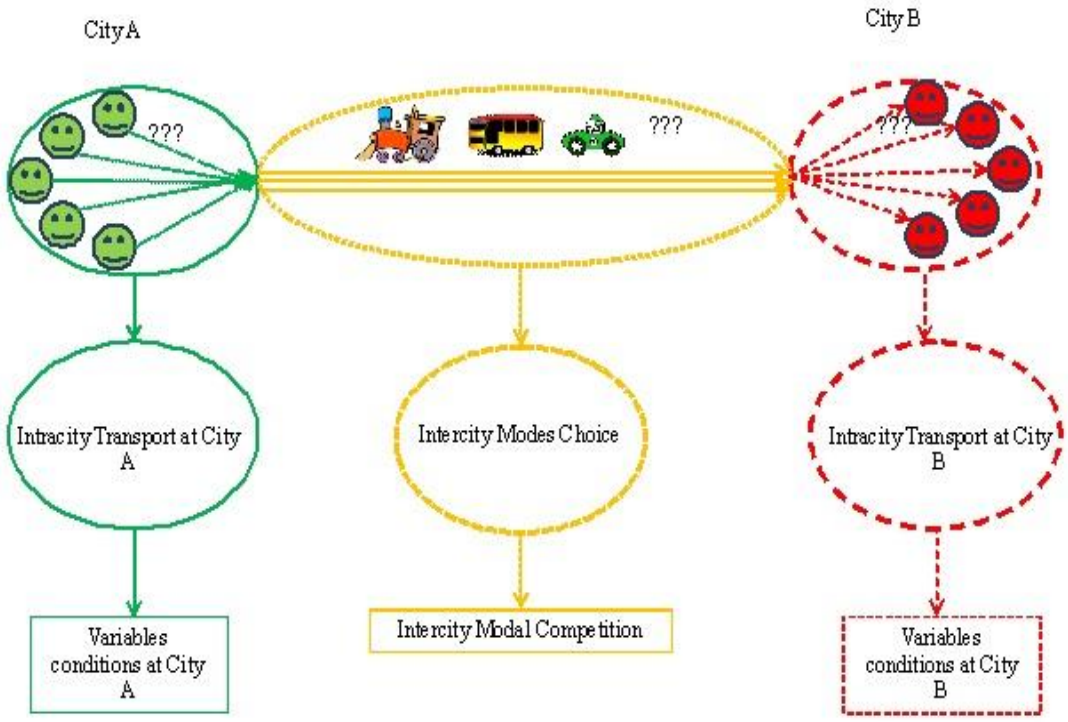


Figure 3.2 The Challenges of Intercity Transport Modes

1. Step 1 is transportation from origin departure city. This step is called intracity public transport at departure city.

Passengers will choose a single transport mode or combination of modes of transport for travel within the city. The choice is a private car or public transport is the mode in which the choice of the type that has the best advantage. All the possibility to choose the mode of transport will be given a value of 1, because passengers would choose only one mode of transport or the alternatives that have multiple modes of combination. For the choice of a private car, then the node mode of transportation in the city of departure is the toll gate. In this trip there are certain costs, time and other transport conditions. Furthermore, for the choice of the minibus, then node modes departure city is pool minibus and to train the node choice mode of transportation in the city is the departure of the train station.

In this case study, it considers the five quality service variables, then the formula as follows:

$$UIO_i = f_{IO}\,(VIO_1, VIO_2, VIO_3, VIO_4, VIO_5) \quad \text{..... (3.1)}$$

Where:

UIO_i	≡	Utility value alternative i		
VIO_1	≡	TtoU	≡	Travel time alternative i
VIO_2	≡	PoU	≡	Price alternative i
VIO_3	≡	SoC	≡	Safety alternative i
VIO_4	≡	IoC	≡	Information alternative i
VIO_5	≡	CoC	≡	Connectivity alternative i
i	≡	Mo	≡	number of alternatives in departure city (Mo_1 ≡ to go to rail station, Mo_2 ≡ to go to minibus pole, Mo_3 ≡ to go to highway toll road)

2. Step 2 is transportation between two modal nodes in each city. This step is called intercity transport.

The passengers have arrived at the highway toll gate, or at the pole or at the rail station, and then they will use the available modes at the modal node.

In this case study, it only considers the four quality service variables. It uses the formula as follows:

$UM = fM(VM_1, VM_2, VM_3, VM_4)$ ……..…….....…. (3.2)

Where:

UM_i	≡			Utility value alternative i
VM_1	≡	TtiU	≡	Travel time alternative i
VM_2	≡	PiU	≡	Price alternative i
VM_3	≡	SiC	≡	Safety alternative i
VM_4	≡	IiC	≡	Information alternative i
i	≡	Mi	≡	number of alternatives in departure city or at arrival city (Mi_1 ≡ train, Mi_2 ≡ minibus, Mi_3 ≡ car)

3. Step 3 is transportation from modal node at arrival city to final destination. This condition is called intracity transport at arrival city.

The passengers have arrived at modal node (highway toll gate, pool minibus, rail station) in arrival city; passengers continue to go to their final destination. They use a private car, and then they go directly to their final destination. The user of public transport, for example minibus or train, then the passengers will switch to other modes. The user of minibus, they might use a mode which provided by the owner of the minibus company, or replaced it by other modes which are available in the arrival city likewise train's passengers.

In this case study, it also considers the five quality service variables, so the formula as follows:

$UID = f_{ID}(VID_{D1}, VID_2, VID_3, VID_4, VID_5)$ …….……...……..... (3.3)

Where:

UID_i	≡			Utility value alternative i
VID_1	≡	TtdU	≡	Travel time alternative i
VID_2	≡	PdU	≡	Price alternative i
VID_3	≡	SdC	≡	Safety alternative i
VID_4	≡	IdC	≡	Information alternative i
VID_5	≡	CdC	≡	Connectivity alternative i
i	≡	M_D	≡	number of alternatives at arrival city (M_{D1} ≡ from rail station, M_{D2} ≡ from minibus pole, M_{D3} ≡ from highway toll road)

3.2. Survey Method

Research method for primary survey is as follow:

1. Data Observation

   The number of observed data to be collected is based on research design

2. Data Collection

   The study surveys part of service users. It was done by sampling method which has sampling criteria.

3. Data Analysis

   Analysis result examined by statistical test result of collected data. Statistical test was used for model development.

3.2.1 Determining Data and Variables

In determining total sample for total respondent, population size was not so important (Eriyanto, 1999). Acceptable sample is not measured from amount of total population. In probability sample, appropriate sample is measured from total sample and not from total population. For probability sample, the population with the same size will treat as the same in the sample. There are three factors were needed to count total sample, such as variation in population, sampling error, and level of confidence. To determine data and variables, this research use the following method as follows (Fig. 3.3):

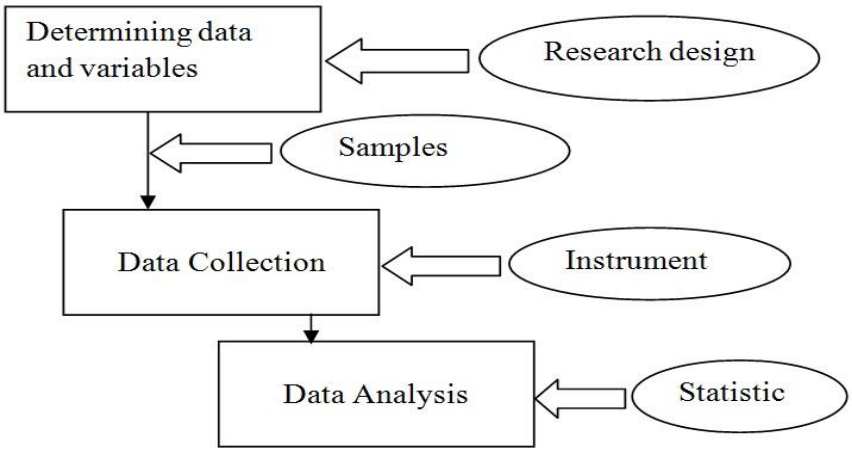


Figure 3.3 Survey Method

Total sample to survey has to fullfill the minimum total sample theoretically with the equation as follow (Eriyanto, 1999):

$N = (pxq) \times (Z^2/E^2)$ ……...……...……..……(3.4)

Where:
N = total sample
(pxq) = variation proportion into population
Z = level of confidence
E = *sampling error* (tolerate error)

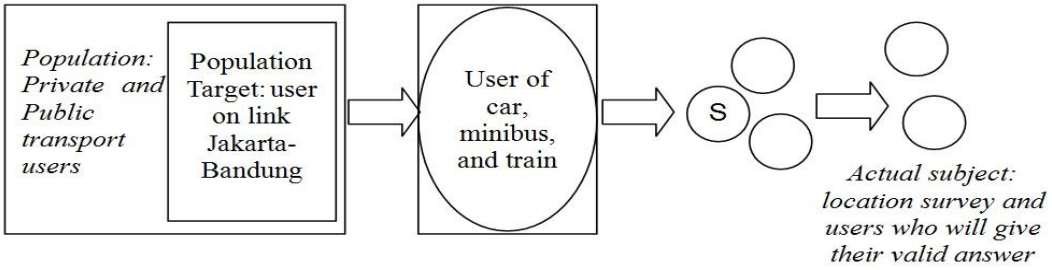


Figure 3.4 Population Target

3.2.2 Respondents with Jakarta Origin

The research divided Jakarta into 5 zones with different distances to. City center and zones determined by administrative boundaries, North, West, Central, South, and East Jakarta. The study sampling method used cluster random sampling, in which the research questionnaires are distributed to 5 zones mentioned above and 5 other zones beyond Jakarta as a control location. Each zone within Jakarta has 17 questionnaires and 9 questionnaires for each control zones, totaling 85 plus 45 questionnaire for Jakarta and beyond respectively.

To anticipate errors during survey, the study add 10% more questionnaires to the sampling. However, due to the number of zones, the study added 10 more questionnaires, instead of 85 for Jakarta questionnaire and 5 more questionnaires for control zones. Thus the number of respondents were (85 +10) + (45 +5) = 145 for 1 intercity point (modal node at departure city). The study analyze 3 intercity

point, which are Highway toll gate, Pole of minibus (shuttle service), and the rail station. In total, the study needs 435 questionnaires for 3 intercity modal node and 29 questionnaires for Jakarta origin for each modal node.

Table 3.1. Samples Quantity

No.	Item	p	q	Z	E	N
a	Model samples	0.16	0.84	1.65	0.066	84
c	Additional samples for zone control					1
d	Error anticipation					10
	Sub total					95
a	External validation samples					42
b	Additional samples for zone control					3
c	Error anticipation					5
	Sub total					50
Total each mode						145
Total three modes each direction						435
Total two directions						870

3.2.3 Respondents with Bandung as Origin

The study also divided Bandung into 5 zones based on the distance that affect the value of access to city center of North, South, East, West, and Center Bandung. The study also uses random sampling method for 5 Bandung zones and 5 control zones beyond Bandung. Given the similarity of origin and control zones, the number of questionnaire for this type of respondent is the same as respondent with Jakarta origin Total there were 435 questionnaires for intercity mode users of Bandung.

In determining the minimum total sample, variation proportion into population (p x q) is based on train variations, which has the smallest data of variation. Private car and minibus was followed this variation to get their minimum total samples. This was done due to fill the sufficient data.

3.3. Questionnaires Survey Results

3.3.1. Survey Location

The last survey was applied for passengers who were interest in traveling between the Jakarta-Bandung corridor. Jakarta area consists of North Jakarta, West Jakarta, Central Jakarta, South Jakarta, and East Jakarta (Fig. 3.5). Location boundaries were needed to be determined because not all modes can give the same services from one zone another. Particularly for railway, its intercity modal node was only serving Jakarta City and Bandung (Fig. 3.6), so location survey became only all zones in Jakarta and Bandung.

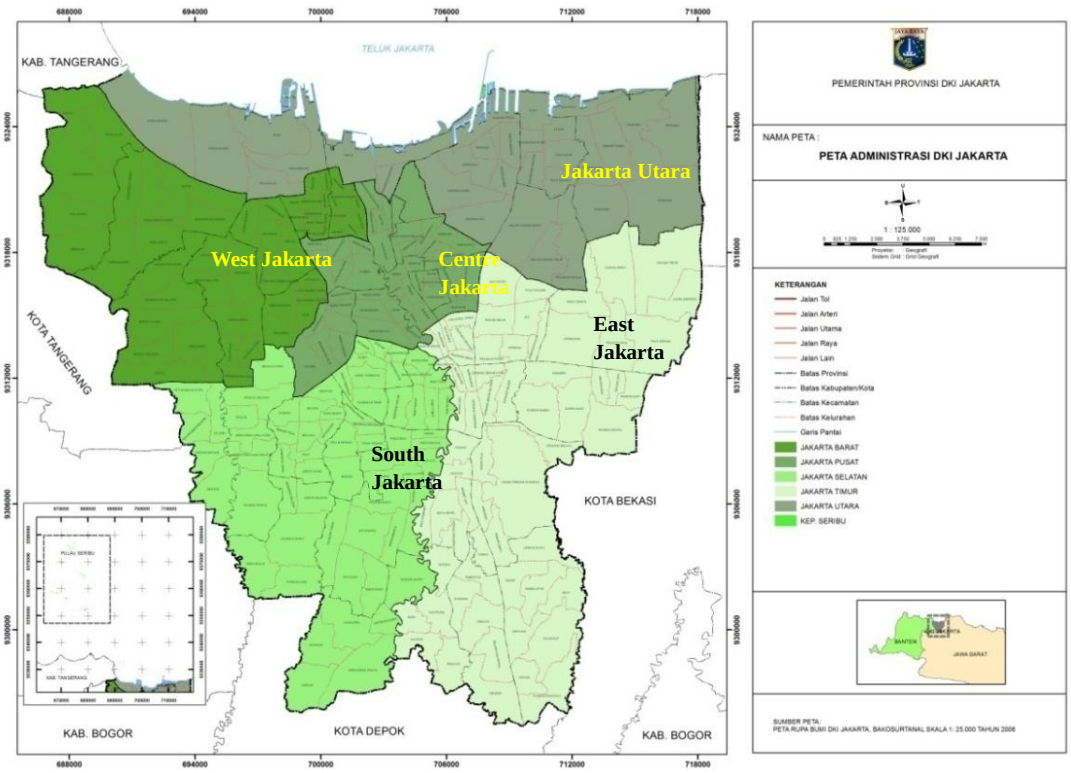


Figure 3.5 Jakarta Zones

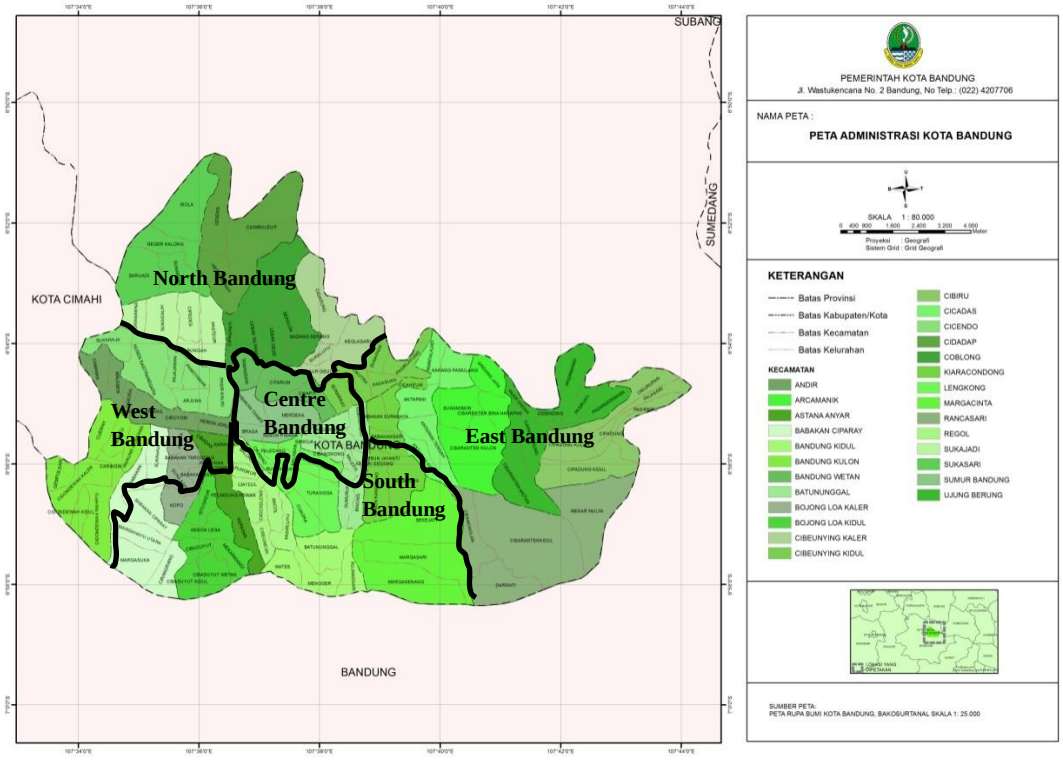


Figure 3.6 Bandung Zones

3.3.2 Data Compilation

In the previous study about "*Estimating Modal Shift of Car Travelers to Bus on Introduction of Bus Priority System*" (Vedagiri P. and Arasan V. T, 2009), it used home-interview survey for collecting data based on the stated preference approach and analyzed the data with a binary logit model of mode-choice method. A home-interview survey was conducted in a residential area, which has reasonable accessibility to bus service (walking time to bus stop varies from 3–15 min). During the survey, the respondents were asked to base their response on their previous day trips.

In the other previous study of "*The use of stated preference techniques to model modal choices on intercity trips in Ireland*" (Ahern et al., 2008), the data collection method used stated preference and revealed preference techniques. Questionnaires were issued on-board in the buses and trains on the Dublin–Sligo

and Dublin–Galway routes. Their two types of state preference questionnaire were ranking and stated choice.

Revealed preference method disadvantage is the choices that are made by respondents are known outcomes, although they are dependent on the respondent's perceptions of attribute levels, which may or may not be accurate (Hensher, 1994). Stated preference studies allow us to examine how decision-making varies as different types of attribute profiles and levels are considered (Hensher, 1994). Its disadvantage is if hypothetical situations are far removed from the respondent's daily experience, the stated preference study will result in poor models and inaccurate results.

Stated preference data allows us to look at preferences in hypothetical situations and to make longer-term evaluations. Pooling stated preference and revealed preference data must be done with great care as not all stated preference studies can be pooled with revealed preference studies. In certain condition, collecting revealed preference data is more accurate than stated preference data.

Previous researchers have used the "stated preference" and "revealed preference" studies to explore different modal attributes. In this research, the same approaches were adopted. Passenger's preference survey was done by personal interview. It is difficult to send the questions by internet facility due to the penetration of computer and internet to Jakarta-Bandung passengers do not have high access to middle and low income group.

3.3.3. Data Verification

Before analyzing the data, it should be tested about its quality. Testing the quality of data is done by verification questionnaire and data adjustment. Questionnaires were produced 900 sheets. They were produced more to anticipate error conditions such as lost, damage, fault, and to use for trial activities. Minimum

questionnaires are amount of samples quantity without error anticipation. After field distribution, then questionnaires have to verify to all their requirements.

Data verification was done by checking data input in excel files with questionnaires requirements as mention in the guideline. Data could missed placed or text format. If there is a respond was not logic then the adjustment is needed. There are some answers that have to fill at “time” column but they filled at “price” column. Data verification was done twice to avoid human error. If there was an error of the answer for one question in the questionnaire and there was not any data to adjust the answer then the questionnaire cannot be analyzed.

Table 3.2 Questionnaires Verification

No.	Samples	Minimum	Production	Verification
1	Jakarta-Bandung direction			
a	Total Model Samples	255	300	288
b	Total External Validation Samples	135	150	165
2	Bandung-Jakarta direction			
a	Total Model Samples	255	300	288
b	Total External Validation Samples	135	150	149
	Total Questionnaires	780	900	890

3.3.4. Data Classification

Numeric data is classified by Sturges equation, so all data format is data rank.

$$k = 1 + 3{,}322 \log n \quad \text{(3.5)}$$

Where:
n ≡ total number of data available
k ≡ number of classification

$$i \equiv r/k \quad \text{(3.6)}$$

i ≡ interval

$$r \equiv \text{value max} - \text{value min} \quad \text{(3.7)}$$

Data was divided into type, such as data for model development and data for external validation. There are two table for model development, such as data Jakarta-Bandung and data Bandung-Jakarta

3.3.5. Statistical Data Descriptions

Total transport chain has 3 steps, intracity transport at departure city, intercity transport between cities and intracity transport at arrival city. Searching data for each link was done by questionnaires distributions. Each link has its own data.

a. Intracity Transport at Departure City

The five variables to validate statistically as follows:

TtoU ≡ Travel time alternative i
PoU ≡ Price alternative i
SoC ≡ Safety alternative i
IoC ≡ Information alternative i
CoC ≡ Connectivity alternative i

Choice data is noted as Mo ≡ number of alternatives in departure city (Mo_1 ≡ to go to rail station, Mo_2 ≡ to go to minibus pole, Mo_3 ≡ to go to highway toll road).

Table 3.3 Descriptive Statistics Intracity at Departure City on Jakarta-Bandung Direction

Variable	N	Minimum	Maximum	Mean	Std. Deviation
TTOU	288	1.00	8.00	6.9757	1.27538
POU	288	1.00	8.00	7.1076	1.22924
SO	288	1.00	6.00	2.9149	.50145
IO	288	1.00	6.00	2.9549	.45690
CO	288	7.00	16.00	12.6319	1.32647
MO	288	1.00	3.00	2.0000	.81792
Valid N (listwise)	288				

Table 3.4 Descriptive Statistics Intracity at Departure City
on Bandung-Jakarta Direction

Variable	N	Minimum	Maximum	Mean	Std. Deviation
TTOU	288	1.00	8.00	6.2188	1.47832
POU	288	1.00	8.00	7.1562	1.21542
SO	288	1.00	4.00	2.9722	.49308
IO	288	1.00	4.00	3.0000	.46479
CO	288	9.00	16.00	12.0833	1.19814
MO	288	1.00	3.00	2.0000	.81792
Valid N (listwise)	288				

b. Intercity Transport between Cities

The four variables on the link as follows:

TtiU ≡ Travel time alternative i
PiU ≡ Price alternative i
SiC ≡ Safety alternative i
IiC ≡ Information alternative i

Choice data is noted as Mi ≡ number of modes available (Mi_1 ≡ train, Mi_2 ≡ minibus, Mi_3 ≡ car).

Table 3.5 Descriptive Statistics on Intercity Jakarta-Bandung Direction

Variable	N	Minimum	Maximum	Mean	Std. Deviation
TTIU	288	1.00	8.00	4.8437	1.60353
PIU	288	1.00	8.00	5.8368	2.28716
SI	288	1.00	4.00	3.0417	.30955
II	288	2.00	4.00	3.0451	.32553
MI	288	1.00	3.00	2.0000	.81792
Valid N (listwise)	288				

Table 3.6 Descriptive Statistics on Intercity Bandung-Jakarta Direction

Variable	N	Minimum	Maximum	Mean	Std. Deviation
TTIU	288	1.00	8.00	4.4340	1.35732
PIU	288	1.00	8.00	4.9896	1.77573
SI	288	2.00	4.00	3.0729	.42348
II	288	2.00	4.00	3.0729	.43163
MI	288	1.00	3.00	2.0000	.81792
Valid N (listwise)	288				

c. Intracity Transport at Arrival City

The five variables on the link as follows:

TtdU	≡	Travel time alternative i
PdU	≡	Price alternative i
SdC	≡	Safety alternative i
IdC	≡	Information alternative i
CdC	≡	Connectivity alternative i

Choice data is noted as M_D ≡ number of alternatives at arrival city (M_{D1} ≡ from rail station, M_{D2} ≡ from minibus pole, M_{D3} ≡ from highway toll road).

Table 3.7 Descriptive Statistics Intracity at Arrival City on Jakarta-Bandung Direction

Variable	N	Minimum	Maximum	Mean	Std. Deviation
TTDU	288	1.00	8.00	6.6493	1.54331
PDU	288	1.00	8.00	6.8368	1.47609
SD	288	1.00	4.00	2.9653	.46348
ID	288	1.00	4.00	3.0313	.38581
CD	288	8.00	16.00	12.6493	1.27093
MD	288	1.00	3.00	2.0000	.81792
Valid N (listwise)	288				

Table 3.8 Descriptive Statistics Intracity at Arrival City on Bandung-Jakarta Direction

Variable	N	Minimum	Maximum	Mean	Std. Deviation
TTDU	288	1.00	8.00	5.5069	2.11019
PDU	288	1.00	8.00	5.9896	2.08944
SD	288	1.00	4.00	2.9792	.46432
ID	288	1.00	4.00	3.0000	.44954
CD	288	9.00	16.00	13.3160	1.05963
MD	288	1.00	3.00	2.0000	.81792
Valid N (listwise)	288				

3.4. Development Model

3.4.1 Model Challenges

Choice of the model should have the following considerations (Ortuzar and Willumsen, 1994 in Tamin, 2000):

1. Decision Level : whether it is strategic, tactic, or operational
2. Accuracy : it will be depend on the accuracy of data
3. Available Data : the model will need certain data to fulfill
4. Model Capacity : how could the model response to the problem
5. Available Resources : available tools and time to run
6. Data Processing Requirement : capacity to collect data, codification, entry data, run program, analysis and interpretation
7. Researcher Capacity : level of educations and experiences

The research of Multi-Modal Transit Services chose the nested logit model (Lo et al., 2004). Their research optimized some routes from one origin (down town) to one destination (airport). They count some transit nodes which are the important place as a transit area from downtown to airport (Fig. 3.7).

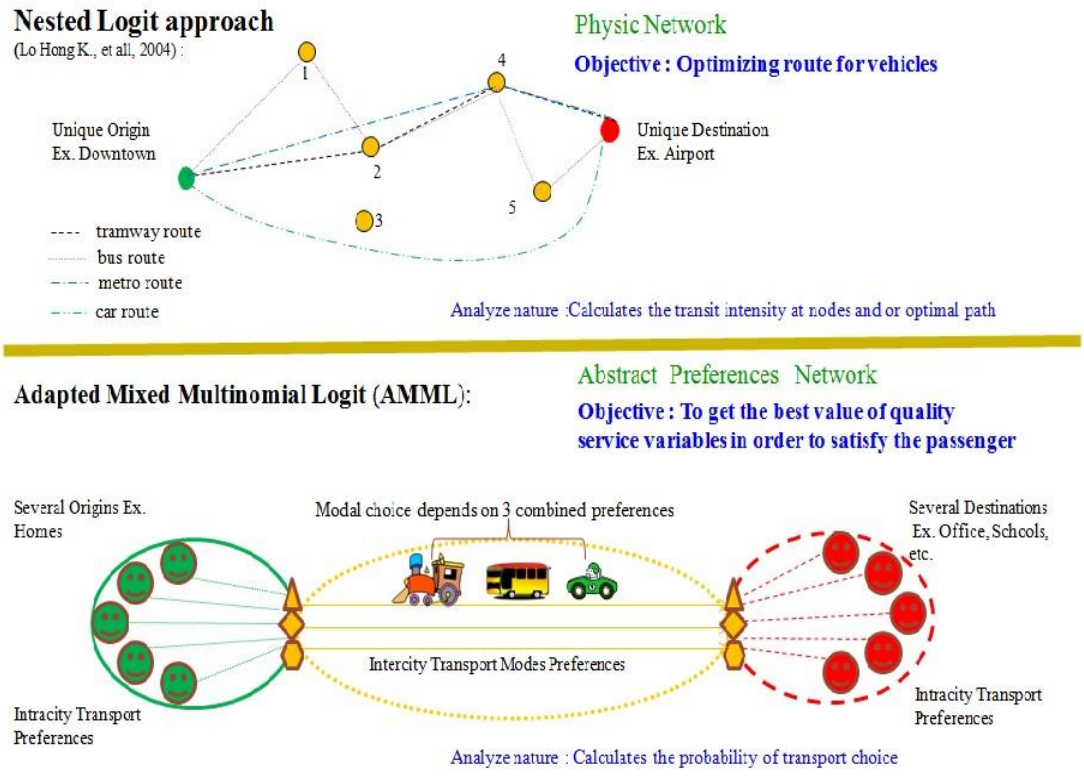


Figure 3.7 Comparison between Nested Logit Approach and the "AMML Model"

Table 3.9 Comparison of Nested Logit Approach and the "AMML Model"

No.	Discuss items	Research of Modeling Competitive Multi-modal Transit Service	Present Research of the Proposed Model "AMML Model"
1.	Method	Nested Logit Approach	Adapted Mix Multinomial Logit Model
2.	Research object (Who/What)	The travel of some vehicles	The travel of passengers
3.	Definition of Origin	The city centre	Origin points are located in some zones at the departure city
4.	Definition of Destination	The airport	Destination points are located in some zones at the arrival city
5.	Definition of Network	Massive network (physical network) and a massive transit points in the proposed network from origin to destination	Abstract network, with 3 step trips, Firstly from the origin to the modal node 1 (the network is not massive and replaced with quality variables values). Secondly the intercity transport itself with a massive network without transit points. Thirdly, from the modal node 2 towards the final destination (the network is not massive and replaced with values of quality variables at the destination)
6.	Results objectives	Calculates the intensity of the transit points on the number of vehicles that will pass by	Identify some significant variables that provide a great opportunity to increase the probability to be chosen over the other mode
7.	Point of interest	The efficiency of the acceptable vehicles by optimizing the routes on the network transfer points (example: tramway, bus, metro, car)	To get the high value from total transport chain. The highest value indicates the highest chance to be chosen by the passengers
8.	Case study area	Hong Kong International Airport to downtown area	Jakarta-Bandung corridor

They concern 5 nodes (1-5) to study. It counted the intensity of the node from the available modes that passed through the node, for example the node 4 has the highest intensity due to all modes of transport passing through by. They were interested to define the physical network from downtown to airport and also it counted the efficiency of one mode to the other, for example tramway, bus, metro and car) which used the physical link. This research cannot compatible with the nested logit model because there are some differences (Table 3.9). The present model focuses on mode services and the choice in total transport. It is based on

study passengers' preferences to choose one intercity mode over the other to travel between cities.

The differences between the research of Modelling Competitive Multi-modal Transit Service and present research was discussed in several items, for example about the method, the research object, definition of origin, definition of destination, definition of network, results objectives, point of interest, and case study area.

3.4.2 The "AMML Model"

The objective of adapted model is to get the appropriate approach to the problem definition. The model can be applied in intercity mode choices in total transport chain. It can consider intracity transport in departure and arrival cities. Intracity mode choices influence passengers' choice when they want to go from one city to another. Position of proposed model can be seen in Fig. 3.8.

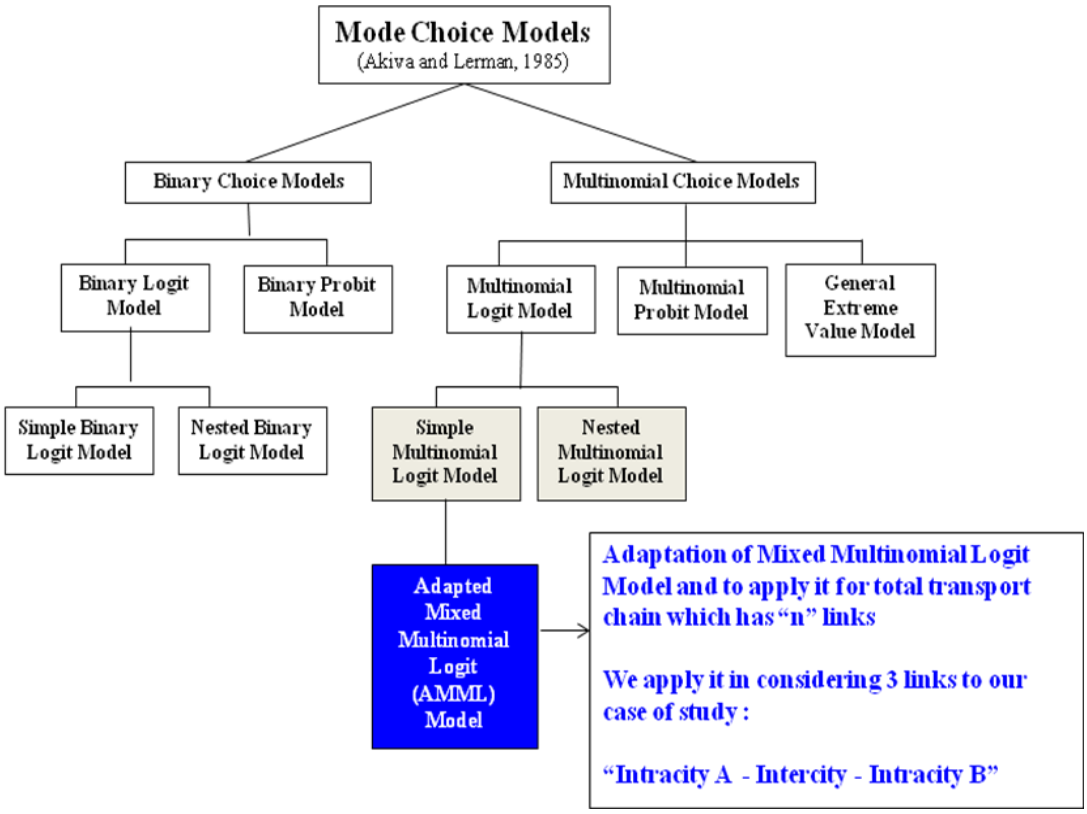


Figure 3.8 Position of Proposed Model among Other Models

A. Modal Choices Calculation in Each Link "Intracity A - intercity - intracity B"

Total transport chain has link "Intracity A - intercity - intracity B". This link has 3 steps, intracity transport at departure city, intercity transport between cities and intracity transport at arrival city (Fig 3.9). Each step has a certain condition. Each mode has to response the condition in each step. Their response will be valued by passengers. The results are the probability value of one mode over the other. There are three probability values. The probability value could be different in each step. The highest value of total probability will be as their choice.

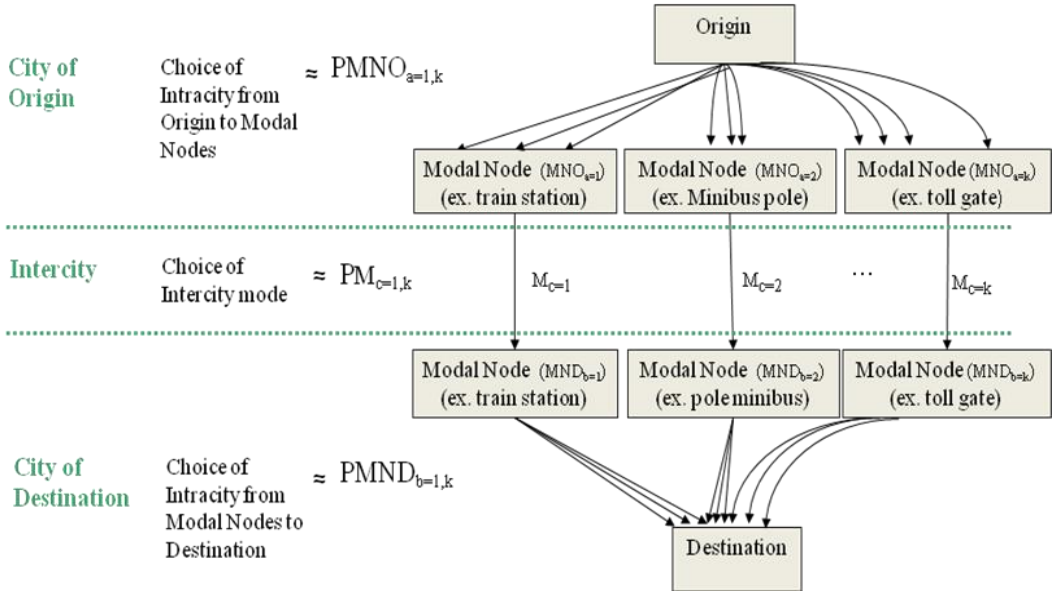


Figure 3.9 Link "Intracity A - Intercity - Intracity B"

1. Probabilities of Intracity Transport at Departure City (calculate $PMNO_{1\text{-}i}$)

Passengers who want to travel from their home to the modal node at departure city will have some choices. They will choose one or more combination modes which meet the maximum advantage for them. If the maximum utility is to go to highway toll gate over the others, then probably they will use a private car. If the maximum utility is to go to minibus pole over the others, then they probably use

one mode or combination of modes to catch minibus pole. If maximum utility is to go to rail station over the others then they probably go by one mode or several combination modes to catch rail station (Fig. 3.10).

The $PMNO_{1\text{-}i}$ is probability to choose one of modal node*) i over the others based on maximum utility of quality service variables values whether with one mode or several combination modes to catch modal node at their departure city. Note *) is assumption that at modal node there is only one type of intercity mode.

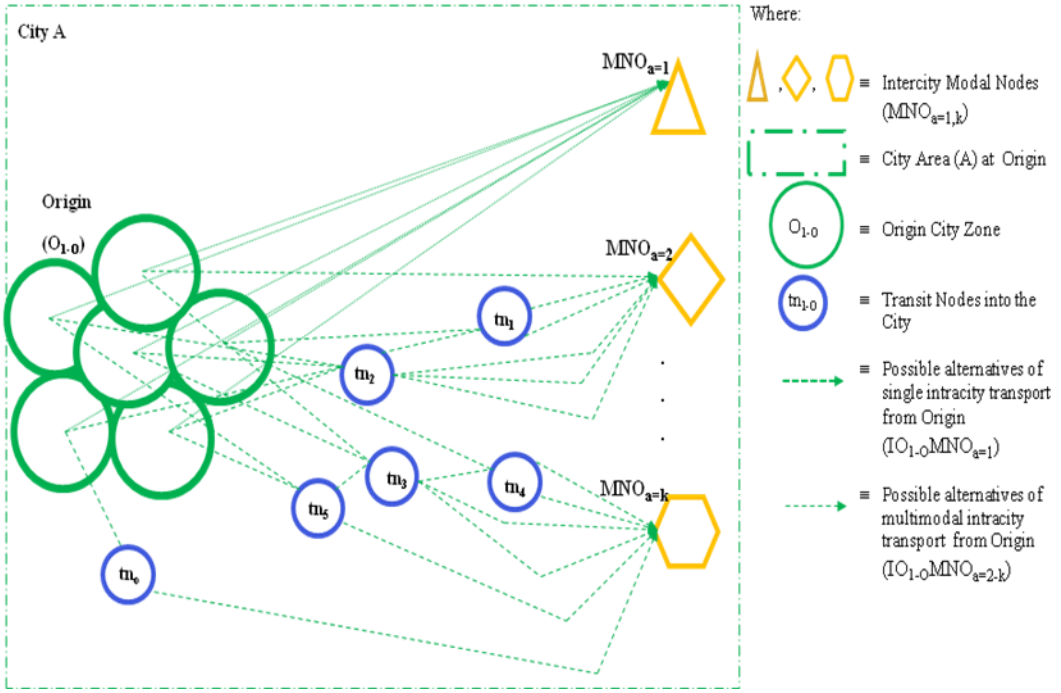


Figure 3.10 Intracity Transport at Departure City

The $PMNO_{1\text{-}i}$'s value can be counted based on multinomial logistic regression with respons variable category, $UIO_1 = 1$ (modal node 1), for one mode or more combination mode in intracity point 1, IO_1, $UIO_2 = 2$, for IO_2, $UIO_k = k$, for IO_k . Independent quality variables are VIO_{11}, VIO_{12}, …, VIO_{1p}. When variable category as a reference $UIO_k = k$, then:

$$Z_1(V) = \ln\left[\frac{PMNO(UIO1=1)}{PMNO(UIOk=k)}\right] = \ln\left[\frac{PMNO(IO1)}{PMNO(IOk)}\right]$$

$$= \beta_{10} + \beta_{11}\, VIO_{11} + \beta_{12}\, VIO_{12} + \ldots + \beta_{1k}\, VIO_{1p} \quad \ldots\ldots(3.8)$$

$$Z_2(V) = \ln\left[\frac{PMNO(UIO2=2)}{PMNO(UIOk=k)}\right] = \ln\left[\frac{PMNO(IO2)}{PMNO(IOk)}\right]$$

$$= \beta_{20} + \beta_{21}\ VIO_{21} + \beta_{12}\ VIO_{22} + \ldots + \beta_{2k}\ VIO_{2p} \quad \text{......(3.9)}$$

…

$$Z_{k-1}(V) = \ln\left[\frac{PMNO(UIO1=k-1)}{PMNO(UIOk=k)}\right] = \ln\left[\frac{PMNO(IOk-1)}{PMNO(IOk)}\right]$$

$$= \beta_{k0} + \beta_{k1}\ VIO_{k1} + \beta_{k2}\ VIO_{k2} + \ldots + \beta_{kp}\ VIO_{kp..} \text{(3.10)}$$

Then:

$$PMNO_{1\text{-}i} = \frac{e^{Z_{1,0}}}{1+e^{Z_1+Z_2+\cdots+Z_{i-1}}} = P_1 \quad \ldots\ldots(3.11)$$

$$PMNO_{2\text{-}i} = \frac{e^{Z_{2,0}}}{1+e^{Z_1+Z_2+\cdots+Z_{i-1}}} = P_2 \quad \ldots\ldots(3.12)$$

…

$$PMNO_{i\text{-}1} = \frac{e^{Z_{k-1,0}}}{1+e^{Z_1+Z_2+\cdots+Z_{i-1}}} = P_{i\text{-}1} \quad \ldots\ldots(3.13)$$

$$PMNO_{i} = \frac{1}{1+e^{Z_1+Z_2+\cdots+Z_{i-1}}} = P_0 \quad \ldots\ldots(3.14)$$

Where:

$P_0 + P_1 + P_2 + \ldots + P_{i\text{-}1} =$ 1
Passenger ≡ 1,2, …, n (index i) with i = 1,2,…,n
UIO category ≡ 1,2,…,k (index j) with j = 1,2,…,k
Independent Variables ≡ VIO_1, VIO_2, …, VIO_p with l = 1,2,…, p

Calculation for $PMNO_{1\text{-}i}$ can be done by considering the presence of quality variables in utility function. Each option requires the data to be calculated for each probability. This option uses maximize utility value. The highest value of utility value has a higher probability to choose. The needed data from survey can be seen at Table 3.10.

Table 3.10 Data from Departure City

No	VIO_1	VIO_2	VIO_3	VIO_p	UIO (category)	$PMNO_1(IO_1)$	…	$PMNO_1(IO_k)$
1	VIO_{111}	VIO_{211}	VIO_{311}	VIO_{n11}	UIO_1	$PMNO_1(IO_1)$	…	$PMNO_1(IO_k)$
2	VIO_{112}	VIO_{212}	VIO_{312}	VIO_{n12}	UIO_2	$PMNO_2(IO_1)$	…	$PMNO_2(IO_k)$
3	VIO_{113}	VIO_{213}	VIO_{313}	VIO_{n13}	UIO_3	$PMNO_3(IO_1)$	…	$PMNO_3(IO_k)$
…	…	…	…	…	…	…	…	…
n	VIO_{11n}	VIO_{21n}	VIO_{31n}	VIO_{n1p}	UIO_n	$PMNO_n(IO_1)$	…	$PMNO_n(IO_k)$

$UIO_o = f_{IO}(VIO_1, VIO_2, VIO_3,\ldots,VIO_p)$ ……………………………………... (3.15)

Where: $VIO_1, VIO_2, VIO_3,\ldots,VIO_p \equiv$ quality variables from departure city

This research, equation of intracity transport accessibility is expressed by utility values of quality variables (UIO_i). In case study, it considers the five quality service variables, then the formula as follows:

$$UIO_i = \beta_0 + \beta_1 P_i + \beta_2 Tt_i + \beta_3 S_i + \beta_4 C_i + \beta_5 In_i \quad \text{.....(3.16)}$$

Where:

UIO_i	≡	Utility value alternative i
P_i	≡	Price alternative i
Tt_i	≡	Travel time alternative i
S_i	≡	Safety alternative i
C_i	≡	Connectivity alternative i
In_i	≡	Information alternative i
i	≡	number of alternatives in departure city or at arrival city
$\beta_0, \beta_1, \ldots \beta_5$	≡	constants

If the variable data (VIO_1, VIO_2, VIO_3,..., VIO_p) and choice (UIO category) were obtained from the survey, then it can be used to estimate the value of constants β_0 and other variables (β_1, β_2 , β_3, ... β_n). Calculations were performed by using the maximum likelihood estimator in the logistic regression method.

$$UIOi(\text{category}) = \frac{e^{\beta o+\beta_1 VIO_1+\beta_2 VIO_2+\beta_s VIO_s,\ldots \beta_n VIOp}}{1+e^{\beta o+\beta_1 VIO_1+\beta_2 VIO_2+\beta_s VIO_s,\ldots \beta_n VIOp}} \quad \text{.....(3.17)}$$

Where :

UIO(category)	≡	modal node at departure city that was chosen
VIO_1, VIO_2, VIO_3,…,VIO_n	≡	quality variables from departure city
$\beta_0, \beta_1, \beta_2, \beta_3, \ldots \beta_n$	≡	estimated constants

Probability with Utility value (UIO) with reference of the eq. 2.14 in chapter 2 as follows:

$$PMNO_{(IOi)} = \frac{e^{UIOi}}{e^{UIOi} + \sum_j^n e^{UIOjn}} \quad \text{.....(3.18)}$$

Where:

$PMNO_{(IOi)}$	≡	Probability of modal node i was chosen from departure city

UIO_i ≡ Utility value from intracity transportation i from departure city to modal node at departure city

$\sum UIO_{jn}$ ≡ total value of utility value from other intracity transportation (j_1,....,j_n) from departure city to modal node at departure city

e ≡ exponential

2. Intracity Transport at Destination (calculate $PMND_{1-j}$)

The $PMND_{1-j}$ is probability to choose of one modal node*) i based on maximum utility of quality service when they choose one mode or several combination modes to catch their destination. Note *) is assumption that at modal node in arrival city, there is only one intercity mode. Maximum utility is counted based on travel conditions at arrival city (Fig. 3.11).

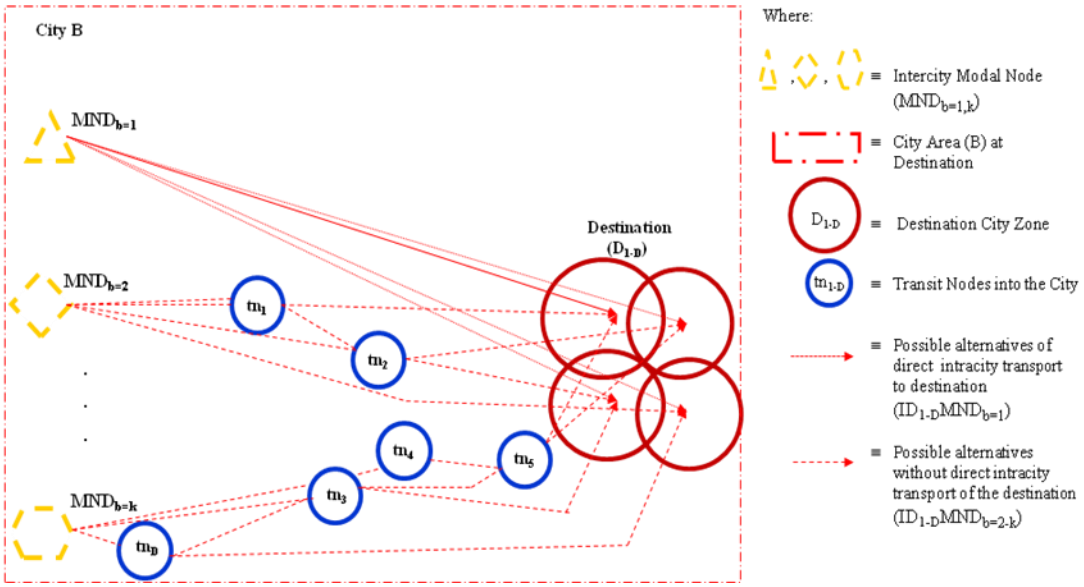


Figure 3.11 Intracity Transport at Arrival City

The calculation $PMND_{1-j}$ can be done by considering the utility value (UID_j). Each of this option also requires the real data from passengers' opinions. To collect a real data, a survey is necessary and can be done by questioning passengers. These passengers must know the intercity transportation patterns. This option uses utility value. The data from survey can be seen at Table 3.11.

Table 3.11 Data at Arrival city

No	VID_1	VID_2	VID_3	VID_p	UID (category)	$PMND_1(ID_1)$	…	$PMND_1(ID_k)$
1	VID_{111}	VID_{211}	VID_{311}	VID_{n11}	UID_1	$PMND_1(ID_1)$	…	$PMND_1(ID_k)$
2	VID_{112}	VID_{212}	VID_{312}	VID_{n12}	UID_2	$PMND_2(ID_1)$	…	$PMND_2(ID_k)$
3	VID_{113}	VID_{213}	VID_{313}	VID_{n13}	UID_3	$PMND_3(ID_1)$	…	$PMND_3(ID_k)$
…	…	…	…	…	…	…	…	…
n	VID_{11n}	VID_{21n}	VID_{31n}	VID_{n1p}	UID_n	$PMND_n(ID_1)$	…	$PMND_n(ID_k)$

$UID = f_{ID}(VID_{D1}, VID_2, VID_3,\ldots,VID_p)$ …………………………………………. (3.19)

Where: $VID_1, VID_2, VID_3,\ldots,VID_p \equiv$ quality variables from arrival city

If the variables data (VID_1, VID_2, VID_3,..., VID_p) and choice (UID category) have been obtained from the survey, then it can be estimated constants β_0 and other variables (β_1, β_2 , β_3, ... β_n). It is calculated by the maximum likelihood estimator in the logistic regression method. $PMND_{(IDi)}$ with reference of the eq. 2.14 in chapter 2 as follows:

$$PMND_{(IDi)} = \frac{e^{UIDi}}{e^{UIDi} + \sum_j^n e^{UIDjn}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.20)$$

Where:

$PMND_{(IDi)}$ ≡ Probability modal node i was chosen at arrival city

UID_i ≡ Utility value from intracity mode i or several combination modes i from modal node at arrival city to final destination

$\sum UID_{jn}$ ≡ total value utility value from other modal nodes (j_1,....,j_n) from modal node at arrival city to final destination

e ≡ exponential

3. Intercity transport (calculate $PM_{1\text{-}k}$)

After all passengers have the clear picture of potential probability from intracity transportation at the departure and destination cities which pointed to one certain mode over the others and before they make a choice, they want to know the characteristic of intercity mode. They count the maximum utility the offering services of one mode over the other. Finally, they would choose one mode over the other if its total probability from departure city, arrival city and intercity mode

is the highest. At this link, passengers can have a direct trip because there is only one mode is available. If one passenger has arrived at modal node at departure city, then they will continue their journey to modal node at arrival city (Fig. 3.12).

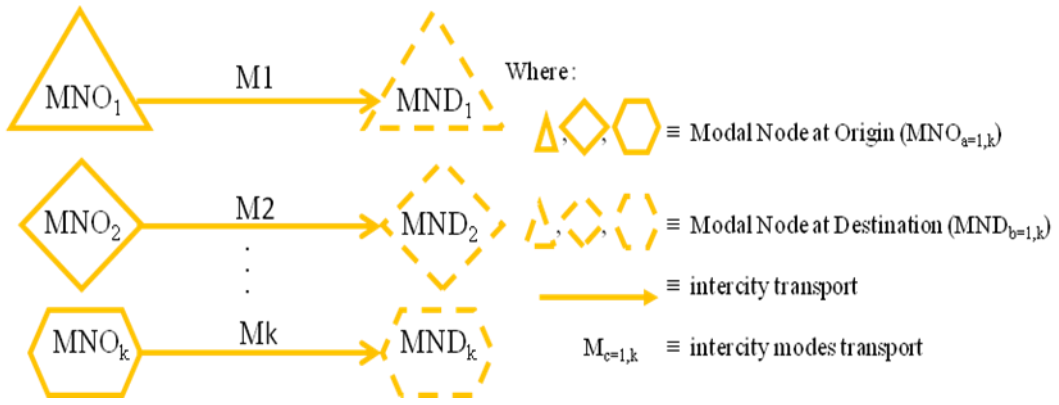


Figure 3.12 Intercity Transport System

Calculation for $PM_{1\text{-}k}$ can also be done by considering the utility value. It requires the data survey to calculate the probability. The data from survey on intercity link can be seen at Table 3.12.

Table 3.12 Data from Intercity Modes

No	VM_1	VM_2	VM_3	VM_p	UM (category)	$PM(M_1)$	…	$PM(M_k)$
1	VM_{111}	VM_{211}	VM_{311}	VM_{n11}	UM_1	$PM_1(M_1)$	…	$PM(M_k)$
2	VM_{112}	VM_{212}	VM_{312}	VM_{n12}	UM_2	$PM_2(M_1)$	…	$PM_2(M_k)$
3	VM_{113}	VM_{213}	VM_{313}	VM_{n13}	UM_3	$PM_3(M_1)$	…	$PM_3(M_k)$
…	…	…	…	…	…	…	…	…
n	VM_{11n}	VM_{21n}	VM_{31n}	VM_{n1p}	UM_n	$PM_n(M_1)$	…	$PM_n(M_k)$

$$Um = fM(VM_1, VM_2, VM_3,\ldots,VM_p) \quad \ldots\ldots (3.21)$$

Where: $VM_1, VM_2, VM_3,\ldots,VM_p \equiv$ quality variables from intercity modes

If the variables in data are VM_1, VM_2, VM_3,..., VM_p and choice (UM category) have been obtained from the survey, then it can be estimated constants β_0 and other variables (β_1, β_2 , β_3, ... β_n). Calculations were performed using the

maximum likelihood estimator in the logistic regression method. PM_{1-k} with reference of the eq. 2.14 in chapter 2 as follows:

$$PM_{1-k} = \frac{e^{UMi}}{e^{UMi} + \sum_{j}^{n} e^{UMjn}} \quad \text{.....(3.22)}$$

Where:
PM_{1-k} ≡ Probability intercity mode i was chosen
UM_i ≡ Utility value from intercity mode i
$\sum UM_{jn}$ ≡ total value utility value from other intercity modes (j_1,....,j_n)
e ≡ exponential

B. Modal Choices Calculation in Total Transport Chain as the Final Choice

Journey behaviour for passengers who want to go from departure city to arrival city has three steps, first departure city to modal node at departure city (IO), modal node at departure city to modal node at arrival city (M), and modal node at arrival city to final destination (ID). Journey behaviour is in a conditional probability with 3 events. Conditional probability with 3 events is as follows (Walpole et al, 2012):

$$P(A_3|A_1 \cap A_2) = \frac{P(A1 \cap A2 \cap A3)}{P(A1 \cap A2)} \quad \text{.....(3.23)}$$

$$P(A_1 \cap A_2 \cap A_3) = P(A_3|A_1 \cap A_2) \,.\, P(A_1 \cap A_2) \quad \text{.....(3.24)}$$

$$P(A_1 \cap A_2 \cap A_3) = P(A_3|A_1 \cap A_2) \,.\, P(A_2|A_1) \,.\, P(A_1) \quad \text{.....(3.25)}$$

$$P(A_1 \cap A_2 \cap A_3) = P(A_1) \,.\, P(A_2|A_1) \,.\, P(A_3|A_1 \cap A_2) \quad \text{.....(3.26)}$$

Where:
$P(A_3|A_1 \cap A_2)$ ≡ Probability of A_3 even which will happened if probabilities of A_1 and A_2 were known
A_1, A_2, A_3 ≡ Events with index hierarchy

People need to do their activities. They have to travel to other city if their activity is not in their city. Before travelling, they observe the transport condition at their city then the transport conditions at the arrival city, then they consider offered services from each mode, and finally they make a final choice (Tamin, 2000).

These 3 evens are in the conditional probability. Conditional probability with 3 steps of decision process by passengers can be formulated as follows:

$$P(M|IO\cap ID) = \frac{P(IO\cap ID\cap M)}{P(IO\cap ID)} \quad \text{...}(3.27)$$

$$P(IO\cap ID\cap M) = P(M|IO\cap ID) \,.\, P(IO\cap ID) \quad \text{.................................}(3.28)$$

$$P(IO\cap ID\cap M) = P(IO) \,.\, P(ID|IO) \,.\, P(M|IO\cap ID) \quad \text{...........................}(3.29)$$

Where:

$P(IO\cap ID\cap M)$	≡	Probability M which will be count after probability IO and ID has been known
$P(IO)$	≡	Probability of one alternative is chosen which is from one mode or several modes combined at departure city
$P(ID\|IO)$	≡	Probability of one alternative is chosen which is from one mode or several modes combined at arrival city after counting probability of one alternative at departure city
$P(M\|IO\cap ID)$	≡	Probability of intercity mode is chosen after counting probability of one alternative at departure city and one alternative at arrival city
IO	≡	Decision process steps 1 from origin to intercity at departure city
ID	≡	Decision process steps 2 from modal node at arrival city to final destination
M	≡	Decision process steps 3 from modal node at departure city to point modal node at arrival city

This formulation model has a "mixed structure". $P(IO\cap ID\cap M)$ as y is a vector of observations, with :

$P(M|IO\cap ID)$ as β is a vector of fixed effects

$P(IO)$ as u_1 is an additional vector 1

$P(ID|OI)$ as u_2 is an other additional vector 2

Final choice depends on total probability from departure city to arrival city, such as decisions at process 1, 2, and 3. Final choice will be the choice with the highest value. The final choice is the results from a conditional probability process (Fig.3.13).

Total probability from departure city to arrival city consists of trip in the departure arrival cities, and intercity transport. Concern to conditional probability eq. 3.27 and eq. of each process eq. 3.28, and eq. 3.29 and then the equation of total probability is as follows:

$$P(IO \cap ID \cap M) = \frac{e^{UIO(i)}}{e^{UIO(i)} + \sum_1^i e^{UIO(n-i)}} \cdot \frac{e^{UID(j)}}{e^{UID(j)} + \sum_1^j e^{UID(n-j)}} \cdot \frac{e^{UM(k)}}{e^{UM(k)} + \sum_1^k e^{UM(n-k)}} \quad \ldots(3.30)$$

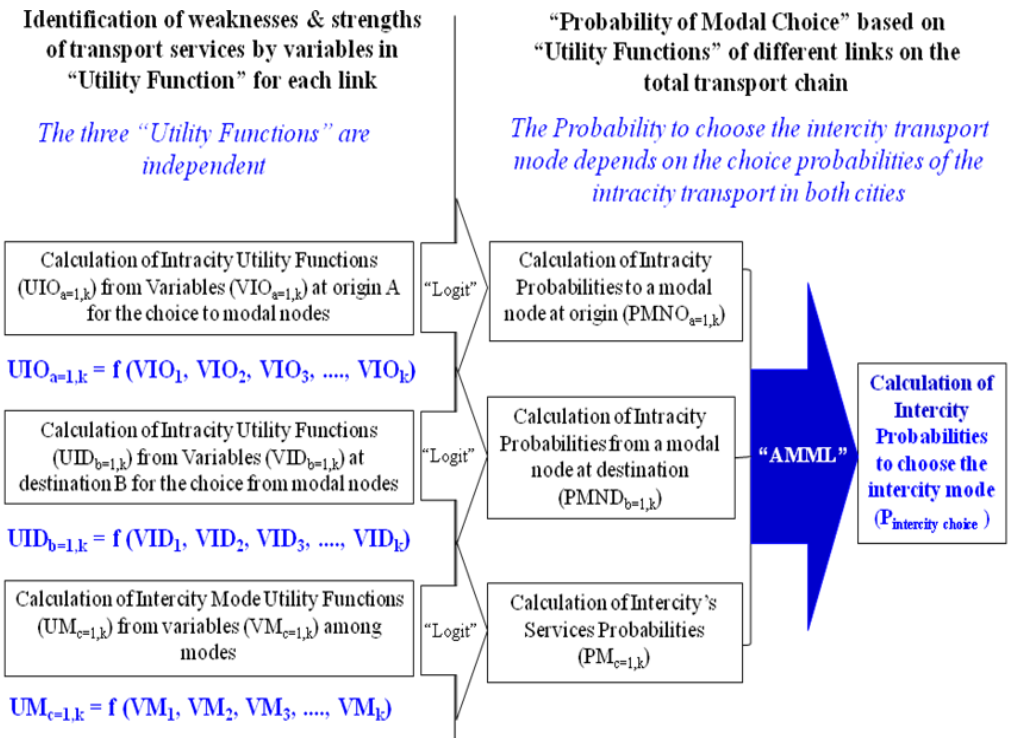


Figure 3.13 Analysis Process in using the "AMML Model"

$$P_{ij}((IO_{i-k}) \cap (ID_{i-k}) \cap (M)_{i-k}) = \frac{e^{UIO_{1-i} + UID_{1-j} + UM_{1-k}}}{\left(e^{UIOi} + \sum_1^i e^{UIO}\right)\left(e^{UIDj} + \sum_1^j e^{UID}\right)\left(e^{UMk} + \sum_1^k e^{UMm}\right)} \quad \ldots\ldots(3.31)$$

Where:

$P((IO_{1-i}) \cap (ID_{1-j}) \cap (M_{1-k}))$	≡	Total probability from departure city to arrival city
UIO_i	≡	Utility value intracity in departure city to modal node at departure city i
UID_j	≡	Utility value from modal node at arrival city to intracity at arrival city j
UM_k	≡	Utility value for intercity mode k
$\sum UIO_{1-i}$	≡	Total utility value other intracity in departure city to modal nodes at departure city ($_1$,....,i)
$\sum UID_{1-j}$	≡	Total utility value other intracity at arrival city from modal nodes at arrival city ($_1$,....,j)

$\sum UM_{1\text{-}k}$ ≡ Total utility value other intercity modes ($_1$,....,k)
e ≡ exponential

General equation of intercity mode choice probability is described on eq. 3.32. This equation is called Adapted Mixed Multinomial Logit (AMML) Model.

$$P_{\text{Intercity mode choice}} = \frac{e^{\sum_{q=1}^{n} UL_q}}{\prod_{q=1}^{n}(e^{UL_q} + \sum_{r=1}^{k} e^{UL_{qr}})} \quad \text{.....(3.32)}$$

Where: $P_{\text{Intercity mode choice}}$ is probability of intercity mode. ULq is each utility value of each link. ΣULqr is a number of utility values from available mode on each link, r is available modes (M1-k), q is link's articulations (I1-n), and e is exponential.

Table 3.13 Data Analysis for Total Probability

No	$P(IO_{1\text{-}i})$	$P(ID_{1\text{-}j})$	$P(M)_{1\text{-}k}$	$P_{ij}((IO_{1\text{-}i})\cap(ID_{1\text{-}j})\cap(M)_{1\text{-}k}$
1	$P(IO_{1\text{-}i})_1$	$P(ID_{1\text{-}j})_1$	$P((M)_{1\text{-}k})_1$	$P_{ij}((IO_{1\text{-}i})\cap(ID_{1\text{-}j})\cap(M_{1\text{-}k})_1$
2	$P(IO_{1\text{-}i})_2$	$P(ID_{1\text{-}j})_2$	$P((M)_{1\text{-}k})_2$	$P_{ij}((IO_{1\text{-}i})\cap(ID_{1\text{-}j})\cap(M_{1\text{-}k})_2$
3	$P(IO_{1\text{-}i})_3$	$P(ID_{1\text{-}j})_3$	$P((M)_{1\text{-}k})_3$	$P_{ij}((IO_{1\text{-}i})\cap(ID_{1\text{-}j})\cap(M_{1\text{-}k})_3$
…	…	…	…	…
n	$P(IO_{1\text{-}i})_n$	$P(ID_{1\text{-}j})_n$	$P((M)_{1\text{-}k})n$	$P_{ij}((IO_{1\text{-}i})\cap(ID_{1\text{-}j})\cap(M_{1\text{-}k})_n$

The "AMML" Model calculates total transport chain probabilities of each intercity transport mode. Adaptation is done by concern to the formulation of additional probability of intracity transport at departure and arrival cities which are influence of the final intercity mode choice.

Possible probabilities results of the of passenger's choice are as follows:

1. If $P(IO_{1\text{-}i})$ high, $P(ID_i)$ high, $P(M_{1\text{-}k})$ high, then $P_i((IO_{1\text{-}i})\cap(ID_i)\cap(M_{1\text{-}k})) > P_j((IO_{1\text{-}i})\cap(ID_{j\text{-}k})\cap(M_{1\text{-}k}))$
2. If $P(IO_{1\text{-}i})$ high, $P(ID_i)$ high, $P(M_{1\text{-}k})$low, then $P_i((IO_{1\text{-}i})\cap(ID_i)\cap(M_{1\text{-}k})) > P_j((IO_{1\text{-}i})\cap(ID_{j\text{-}k})\cap((M_{1\text{-}k}))$
3. If $P(IO_{1\text{-}i})$ high, $P(ID_i)$ low, $(M_{1\text{-}k})$) low, then $P_i((IO_{1\text{-}i})\cap(ID_i)\cap(M_{1\text{-}k})) > P_j((IO_{1\text{-}i})\cap(ID_{jk})\cap((M_{1\text{-}k}))$

4. If $P(IO_{1-i})$ low, $P(ID_i)$ low, $P(M_{1-k})$ high, then $P_i((IO_{1-i}) \cap (ID_i) \cap (M_{1-k})) > P_j((IO_{1-i}) \cap (ID_{jk}) \cap (M_{1-k}))$
5. If $P(OI_i)$ low, $P(ID_i)$ high, $P(M_i)$ high, then $P_i((OI_i) \cap (D_i) \cap (M)_i) > P_j((OI_{j-k}) \cap (ID_{jk}) \cap ((M_{1-k}))$

Total possibilities that would occur without the passenger's choice are as follows:

1. $P(OI_i)$ low, $P(ID_i)$ low, $P(M_{1-k})$ low, then $P_i((OI_i) \cap (ID_i) \cap (M_{1-k}) < P_j((OI_{j-k}) \cap (ID_{j-k}) \cap (M_{1-k}))$
2. $P(OI_i)$ high, $P(ID_i)$ high, $P(M_{1-k})$ low, then $P_i((OI_i) \cap (ID_i) \cap (M_{1-k}) < P_j((OI_{j-k}) \cap (ID_{j-k}) \cap (M_{1-k}))$
3. $P(OI_i)$ high, $P(ID_i)$ low, $P(M_{1-k})$ low, then $P_i((OI_i) \cap (ID_i) \cap (M_{1-k})) < P_j((OI_{j-k}) \cap (ID_{j-k}) \cap ((M_{1-k}))$
4. $P(OI_i)$ low, $P(ID_i)$ low, $P(M_{1-k})$ high, then $P_i((OI_i) \cap (ID_i) \cap (M_{1-k}) < P_j((OI_{j-k}) \cap (ID_{j-k}) \cap ((M_{1-k}))$
5. $P(OI_i)$ low, $P(ID_i)$ high, $P(M_{1-k})$ high, then $P_i((OI_i) \cap (ID_i) \cap (M_{1-k})) < P_j((OI_{j-k}) \cap (ID_{j-k}) \cap (M_{1-k}))$

3.5. Validation Model

The mathematical models obtained are tested by some statistical tests. If the values are acceptable, then the mathematical models can be used for evaluation. Furthermore, the models need to be validated. Validation is done by calculating results with using the AMML Model. There are 2 ways to validate the obtained models. First is by using other equations of the AMML model. It is the probability model which formulated with combination between some constants and utility function. The second is using the new additional data to confirm the choice results.

3.5.1 Validation with Other Equation of the AMML Model

1. Intracity transport at departure city (calculate $PMNO_{1-i}$)

Calculation for $PMNO_{1-i}$ with other equation can be done by considering the influence of certain constants (ρIO). The constants are determined by a formula that depends on certain level of service in catching modal node at departure city. Passengers will choose alternative at intracity transport that has the highest constant (ρIO) value.

$\rho IO = gIO\ (VIO_1, VIO_2, VIO_3,\dots,VIO_p)$ ………………………..................……(3.33)

Where $VIO_1, VIO_2, VIO_3,\dots,VIO_p \equiv$ quality variables from departure city

Constant (ρ_i) values consider level of service of intracity transport alternatives. The equation is as follows:

$\rho_i = g\ (P_i, Tt_i, S_i, C_i, In_i)$ ……………………….......……………………….…...(3.34)

Where:

ρ_i ≡ constants of quality variables value from alternative i at departure city to modal node or from modal node to arrival city

g ≡ function

P_i ≡ Price of alternative i

Tt_i ≡ Travel time of alternative i

S_i ≡ Safety of alternative i

C_i ≡ Connectivity of alternative i

In_i ≡ Information of alternative i

$$\rho_i = \frac{n}{\Sigma_i^n P_i} * \frac{n}{\Sigma_i^n Tt} * \frac{\Sigma_i^n S_i}{n} * \frac{\Sigma_i^n C_i}{n} * \frac{\Sigma_i^n In_i}{n} \quad \text{….(3.35)}$$

The eq. (3.35) can be changed to be congruent as follows:

$$e^{\rho i} = \frac{e^n}{e^{\Sigma_i^n P_i}} * \frac{e^n}{e^{\Sigma_i^n Tt_i}} * \frac{e^{\Sigma_i^n S_i}}{e^n} * \frac{e^{\Sigma_i^n C_i}}{e^n} * \frac{e^{\Sigma_i^n In_i}}{e^n} \quad \text{.....(3.36)}$$

$$e^{\rho i} = \frac{e}{e^{\Sigma_i^n P_i + n\Sigma_i^n Tt_i}} * \frac{e^{\Sigma_i^n S_i + \Sigma_i^n C_i + \Sigma_i^n In_i}}{e^n} \quad \text{…....….(3.37)}$$

$$e^{\rho i} = \frac{e^{\Sigma_i^n S_i + \Sigma_i^n C_i + \Sigma_i^n In_i}}{e^{\Sigma_i^n P_i + \Sigma_i^n Tt_i}} \quad \text{…………….……………………...……….(3.38)}$$

$$e^{p_i} = \frac{e^{\sum_i^n (S_i+C_i+In_i)}}{e^{\sum_i^n (P_i+Tt_i)}} \quad \text{.....(3.39)}$$

$$\ln p_i = \ln \sum_i^n (S_i+C_i+In_i) - \ln \sum_i^n (P_i+Tt_i) \quad \text{.....(3.40)}$$

$$p_i = e^{\ln \Sigma in\,(Si+Ci+Ini) - \ln \Sigma in\,(Pi+Tti)} \quad \text{..... (3.41)}$$

Where:

p_i ≡ Constant value alternative i
P_i ≡ Price alternative i
Tt_i ≡ Travel time alternative i
S_i ≡ Safety alternative i
C_i ≡ Connectivity alternative i
In_i ≡ Information alternative i
i ≡ Alternatives i in departure and arrival city
e ≡ exponential
ln ≡ logarithm natural

If the constants are already known (Table 3.14), then it can calculate the probability of one modal node over the others by multinomial logit odds regression with the reference the eq. 2.14 in chapter 2 as follow:

$$PMNO_{(IOi)} = \frac{e^{pIOi}}{e^{pIOi} + \sum_j^n e^{pIOjn}} \quad \text{.....(3.42)}$$

Where:

$PMNO_{(IOi)}$ ≡ Probability modal node i was chosen at departure city
p_{IOi} ≡ constant p from intracity transportation at departure city to modal node at departure city
$\sum p_{IOjn}$ ≡ total value constant p from other intracity transport alternatives (j_1,....,j_n) from origin (home) to modal node at departure city
e ≡ exponential

Table 3.14 Data for Calculating Constants from Alternatives at Departure City

No	VIO_1	VIO_2	VIO_3	VIO_p	Constant pIO	UIO (category)	$PMNO_1$ (IO_1)	…	$PMNO_1$ (IO_k)
1	VIO_{111}	VIO_{211}	VIO_{311}	VIO_{n11}	pIO_{11}	UIO_1	$PMNO_1$ (IO_1)	…	$PMNO_1$ (IO_k)
2	VIO_{112}	VIO_{212}	VIO_{312}	VIO_{n12}	pIO_{12}	UIO_2	$PMNO_2$ (IO_1)	…	$PMNO_2$ (IO_k)
3	VIO_{113}	VIO_{213}	VIO_{313}	VIO_{n13}	pIO_{13}	UIO_3	$PMNO_3$ (IO_1)	…	$PMNO_3$ (IO_k)
…	…	…	…	…	…	…	…	…	…
n	VIO_{11n}	VIO_{21n}	VIO_{31n}	VIO_{n1p}	pIO_{1n}	UIO_n	$PMNO_n$ (IO_1)	…	$PMNO_n$ (IO_k)

2. Intracity Transport at Arrival city (calculate $PMND_{1-j}$)

The calculation $PMND_{1-j}$ can be done by considering the influence of certain constants (βID_i). In this option, constant value of βID is counted using certain equation (see eq. 3.41). Passengers will prefer alternative intracity that has the highest β_D value. Identified data from passengers' preference can be seen at Table 3.15.

$\beta ID = gID\ (VID_1, VID_2, VID_3,\ldots,VID_p)$ ……(3.43)

Where $VID_1, VID_2, VID_3,\ldots,VID_p \equiv$ variables of quality service at arrival city

Table 3.15 Data for Calculating Constants from Alternatives at Arrival City

No	VID_1	VID_2	VID_3	VID_p	Constant βID	UID (category)	$PMND_1$ (ID_1)	…	$PMND_1$ (ID_k)
1	VID_{111}	VID_{211}	VID_{311}	VID_{n11}	βID_{11}	UID_1	$PMND_1$ (ID_1)	…	$PMND_1$ (ID_k)
2	VID_{112}	VID_{212}	VID_{312}	VID_{n12}	βID_{12}	UID_2	$PMND_2$ (ID_1)	…	$PMND_2$ (ID_k)
3	VID_{113}	VID_{213}	VID_{313}	VID_{n13}	βID_{13}	UID_3	$PMND_3$ (ID_1)	…	$PMND_3$ (ID_k)
…	…	…	…	…	…	…	…	…	…
n	VID_{11n}	VID_{21n}	VID_{31n}	VID_{n1p}	βID_{1n}	UID_n	$PMND_n$ (ID_1)	…	$PMND_n$ (ID_k)

If the constants are already known, then the probability of one mode over the other modes can be calculated with the reference the eq. 2.14 in chapter 2:

$$PMND_{(IDi)} = \frac{e^{\beta IDi}}{e^{\beta IDi} + \sum_j^n e^{\beta IDjn}} \quad \ldots\ldots(3.44)$$

Where:

$PMND_{(IDi)} \equiv$ Probability modal node i was chosen at arrival city

$\beta ID_i \equiv$ constant β from intracity transportation i from modal node at arrival city to final destination

$\sum \beta ID_{jn} \equiv$ total value constant β from other modal nodes ($j_1,\ldots,j_n$) from modal node at arrival city to final destination

$e \equiv$ exponential

3. Intercity transport (calculate PM_{1-k})

Calculation for $PM_{1\text{-}k}$ can also be done by considering the influence of certain constants (p̧M). In this option, value of p̧M is counted by using utility function with reference eq.2.3 in chapter 2. Passengers will search alternative intercity that has the highest p̧M. It is essential to get the data from passengers' preference survey (see Table 3.16).

p̧M = gM (VM_1, VM_2, VM_3,…,VM_p) ………………………..……..……(3.45)

Where: VM_1, VM_2, VM_3,…,VM_p ≡ quality variables from intercity modes

Table 3.16 Data for Calculating Constants of Intercity Modes

No	VM_1	VM_2	VM_3	VM_p	Constant p̧M	UM (category)	PM_1 (M_1)	…	PM_1 (M_k)
1	VM_{111}	VM_{211}	VM_{311}	VM_{n11}	p̧M_{11}	UM_1	PM_1 (M_1)	…	PM_1 (M_k)
2	VM_{112}	VM_{212}	VM_{312}	VM_{n12}	p̧M_{12}	UM_2	PM_2 (M_1)	…	PM_2 (M_k)
3	VM_{113}	VM_{213}	VM_{313}	VM_{n13}	p̧M_{13}	UM_3	PM_3 (M_1)	…	PM_3 (M_k)
…	…	…	…	…	…	…	…	…	…
n	VM_{11n}	VM_{21n}	VM_{31n}	VM_{n1p}	p̧M_{1n}	UM_n	PM_n (M_1)	…	PM_n (M_k)

If the constants are already known, it can calculate the probability of one mode relative to other modes of multinomial logit odds with the reference the eq. 2.14 in chapter 2:

$$PM_{(Mi)} = \frac{e^{\text{p̧}Mi}}{e^{\text{p̧}M} + \sum_j^n e^{\text{p̧}Mjn}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.46)$$

Where:

$PM_{(Mi)}$ ≡ Probability intercity mode i was chosen

p̧M_i ≡ constant p̧ from intercity mode i

∑p̧M_{jn} ≡ total value constant p̧ from other intercity mode (j_1,....,j_n)

e ≡ exponential

4. Final Choice Calculation

Concern to eq. 3.30 conditional probability and equations of each process eq. 3.42, eg. 3.44, and eq. 3.46, then:

$$P(IO \cap ID \cap M) = \frac{e^{\mu IOi}}{e^{\mu IOi} + \sum_j^n e^{\mu IOjn}} \cdot \frac{e^{\mu IDi}}{e^{\mu IDi} + \sum_j^n e^{\mu IDjn}} \cdot \frac{e^{\mu Mi}}{e^{\mu M} + \sum_j^n e^{\mu Mjn}} \quad \text{.....(3.47)}$$

$$P_{ij}((IO_{i-k}) \cap (ID_{i-k}) \cap (M)_{i-k}) = \frac{e^{\mu IOi + \mu IDi + \mu Mi}}{\left(e^{\mu IOi} + \sum_j^n e^{\mu IOjn}\right)\left(e^{\mu IDi} + \sum_j^n e^{\mu IDjn}\right)\left(e^{\mu M} + \sum_j^n e^{MIjn}\right)} \quad \text{.....(3.48)}$$

Where:

$P_{ij}((IO_{i-k}) \cap (ID)_{i-k} \cap (M_{i-k})) \equiv$ Total probability from departure city to arrival city

$\mu IO_i \equiv$ Constant μ intracity in departure city to modal node at departure city i

$\mu ID_i \equiv$ Constant μ from modal node at arrival city to intracity at arrival city i

$\mu M_i \equiv$ Constant μ for intercity mode i

$\sum \mu IO_{jn} \equiv$ Total value constant μ other intracity in departure city to other modal nodes at departure city $(j_1,....,j_n)$

$\sum \mu ID_{jn} \equiv$ Total value constant μ other intracity at arrival city from other modal nodes at arrival city $(j_1,....,j_n)$

$\sum \mu M_{jn} \equiv$ Total value constant μ other intercity modes $(j_1,....,j_n)$

i $\equiv$ moda 1,2,3,…k

e $\equiv$ exponential

3.5.2 Validation with New Data (External Validation)

Validation with new data is done to the first and the second equations of "AMML Model". The analysis needs data as in Table 3.17, Table 3.18 and Table 3.19. From Table 3.17, each mode will have 2 values U (category), which is derived from the U_{11} until U_{11k} forecast by a mathematical model that have been resulted and U_{21} until U_{21k} that based on survey results. It might be U_{11} is not always the same as U_{21}.

Table 3.17 Data for Validation of First Equation of "AMML Model"

n	Utility value U	Run Model Result (R)	U_{12} (category) Model Result (U_{12})		U_{12k} (category) Model Result (U_{12k})		U_{22} (category) Survey Result (U_{22})		U_{22k} (category) Survey Result (U_{22k})
1	U_{11}	R_{11}	U_{121}	…	U_{12k1}	…	U_{221}	…	U_{22k1}
2	U_{12}	R_{12}	U_{122}	…	U_{12k2}	…	U_{222}	…	U_{22k2}
3	U_{13}	R_{13}	U_{123}	…	U_{12k3}	…	U_{223}	…	U_{22k3}
…	…	…	…	…	…	…	…	…	…
n	U_{1n}	R_{1n}	U_{12n}	…	U_{12kn}	…	U_{22n}	…	U_{22kn}
			U_{12} %	…	U_{12k} %	…	$U_{22\%}$	…	U_{22k} %

Next analysis is to determine the delta and the percentage of U_{11}'s values which have the same values to U_{21}. If the differences are not many, the models could consider being valid. Similar analysis is also applied for the second equation of "AMML Model" (Table 3.18). Then, the value results are compared from First and Second Equation where the higher values indicate as better equation to use (Table 3.19).

Table 3.18 Data for Validation of Second Equation of "AMML Model"

No	Constant p	Run Model Result (R)	U_{11} (category) Model Result ($U1_1$)		U_{11k} (category) Model Result (U_{11k})		U_{21} (category) Survey Result (U_{21})		U_{21k} (category) Survey Result (U_{21k})
1	p_{11}	R_{11}	$U1_{11}$	…	U_{11k1}	..	$U1_{211}$	…	U_{21k1}
2	p_{12}	R_{12}	$U1_{12}$	…	U_{11k2}	..	U_{212}	…	U_{21k2}
3	p_{13}	R_{13}	U_{13}	…	U_{11k3}	..	U_{213}	…	U_{21k3}
…	…	…	…	…	…	..	…	…	…
n	p_{1n}	R_{1n}	$U1_{1n}$	…	U_{11kn}	..	U_{21n}	…	U_{21kn}
			U_{11} %	…	U_{11k} %	..	$U_{21\%}$	…	U_{21k} %

Table 3.19 Data for Comparison Results of the First and the Second Equation

No	U_1 and U_2 % from Model Result of Option 1 and 2			
	Possibility Result 1	Recommendation for Possibility Result 1	Possibility Result 2	Recommendation for Possibility Result 1
1	$U_{11\ Model\ 1} > U_{21\ Model\ 2}$	Model 1.1 better	$U_{21\ Model\ 2} > U_{11\ Model\ 1}$	Model 2.1 better
2	$U_{12\ Model\ 1} > U_{22\ Model\ 2}$	Model 1.2 better	$U_{22\ Model\ 2} > U_{12\ Model\ 1}$	Model 2.2 better
3	$U_{13\ Model\ 1} > U_{23\ Model\ 2}$	Model 1.3 better	$U_{23\ Model\ 2} > U_{13\ Model\ 1}$	Model 2.3 better
…	…	…	…	…
k	$U_{1k\ Model\ 1} > U_{2k\ Model\ 2}$	Model 1.k better	$U_{2k\ Model\ 2} > U_{1k\ Model\ 1}$	Model 2.k better

3.6. Model Limitations

The use of logit method is very popular on the method of choice of vehicle use and route choice of road network, but this method has grown rapidly in other areas. In this research, the researcher used this method in using choices from passengers. Passengers used one package mode of transport for their travelling

from home to their final destination. They never used other packages and already know the pattern and gave their opinions. Error might occur with some opinions which are not in this pattern.

The existence of a complex system of society led to the handling of public transport services which is viewed from the side of technology, design, and the existing transportation system. Characteristics of multi-disciplinary fields of transportation science are inseparable from the role of a real transportation system involving various sectors of activity, such as socio-economic activities of urban society (Soehodho, 2000). These activities are in line with the time complexity of the problems that requires of the completion.

It considers the nature and characteristics of the transportation problem that is inherent to society itself, so it needs to be seen comprehensively. In this research, the authors developed a model oriented in the context of transport policy-making in transport demand using a variety of alternative models, alternative assumptions, theories, analytical methods, parameters and test the model. The development of model however needs more data and details picture of the situations.

Discussing the problems of the private and public transport service in Indonesia is incomplete without other disciplines. In advance usage, this method could applied to determine the market segments of transportation, such as particular passengers characteristic that were chosen because of several variables that really stands out among certain characteristic. For example, it can use to determine the choice of young people from their departure city to their final destination. It also can use to determine the choice of certain people with the same class income who travel from some links articulations. The total probability function is could be implemented in real condition that always has a possible situation to change its equations.

CHAPTER IV THE "AMML MODEL" APPLICATION

4.1 Research Design

4.1.1 Primary Survey by Questionnaires Distribution

The research was conducted by eight phases (Fig. 4.1). Firstly, literature study gave insight knowledge on general problems base on experts' theories, premises, and opinions in books, study report, and journals papers. Secondly, their written report was discussed to obtain the main and significant problems and method to implement. Thirdly, all input was to assist of developing the questionnaires in and methodology to distribute. Before distributing questionnaires, it was necessary to survey the location and to do some simulation to make sure the implementation. The survey was done on the Jakarta-Bandung corridor targeting passenger of three modes of transportation. This research use the "AMML model" for data analysis, which were validated with some probability models scenarios. The final results were interpreted and were formulated into policy recommendations to improve services of private and public transport modes.

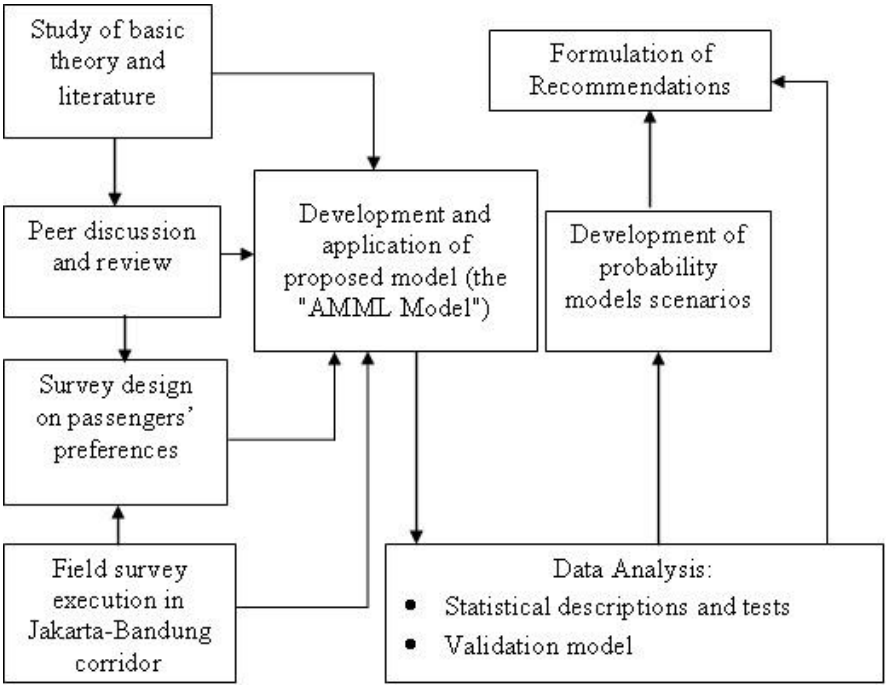


Figure 4.1 Procedure Analysis

Research anatomy was as follow:

- Research issues were indicated by problems on modes' services conditions of private and public transport that are not really good in current situation (Fig. 4.2).
- Research significance to do the research was the needed actions for improvement modes services with supports of intracity transport systems on the Jakarta-Bandung corridor.
- Research classification as follow (Fig. 4.3):
  - Primary survey was done for applying model development (action research)
  - Problem characteristic was descriptive correlation research
  - Character and data type were empirical research and opinion (passengers preferences)
  - Research methods were literature study, field survey, and questionnaires distribution.
- Benefit to be achieved in this activity is identified recommendations to better improve supply conditions both private and public transport services in Jakarta-Bandung corridor (Fig. 4.4)
- Implication: it was necessary to develop and to improve supply condition to be sustainable in the future (Fig. 4.5).

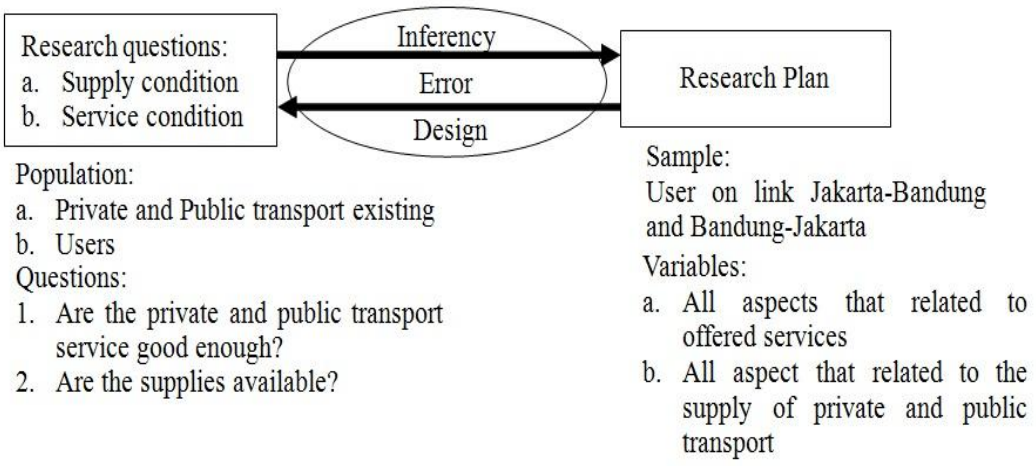


Figure 4.2 Private and Public Transport Modes on the Jakarta-Bandung Corridor

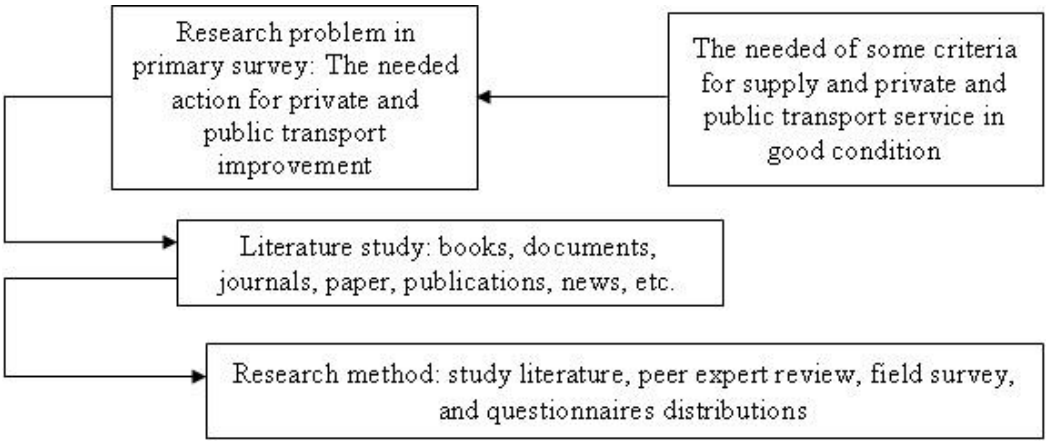


Figure 4.3 Research Anatomy

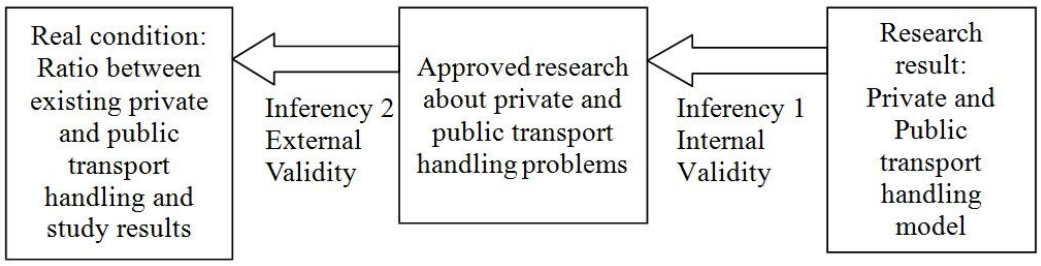


Figure 4.4 Physiology of Decision Making

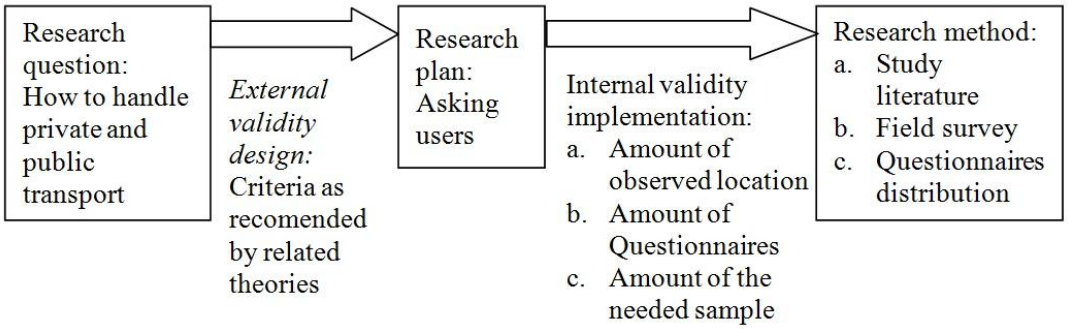


Figure 4.5 Psychology Design/Implementation

4.1.2 Concept Framework

This chapter elaborates the concept framework from general transport problem to more detail case study. Research framework to identify research activities from

the beginning to the end are also discusses. There were some surveys that had been taken as preliminary case studies which are very useful for experience in the field. The primary survey results have inputs in the development of priorities, standards, limitations, relations, and global picture of transport modal competition. Concept framework is developed in iteratively process (Fig. 4.6).

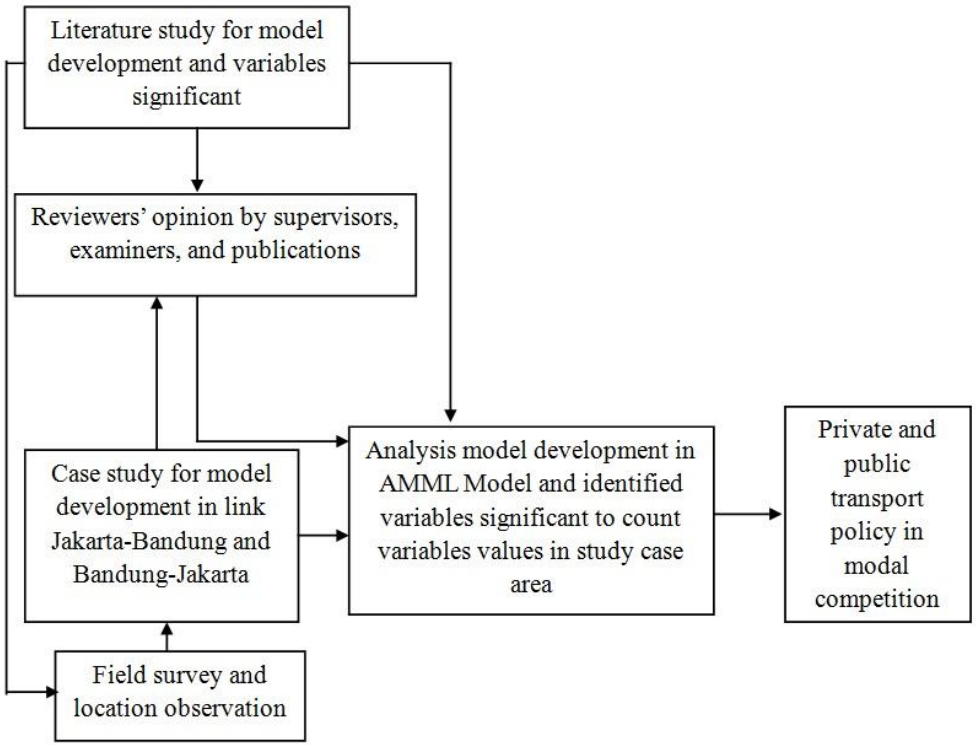


Figure 4.6 Concept Framework

1. Case study for model development on the Jakarta-Bandung corridor

   Revised model development and significant variables were tested again in case study area for passenger's preferences on the direction Jakarta-Bandung and the direction Bandung-Jakarta. It was necessary to elaborate again literature and field study condition (Fig.4.7).
2. Field survey and location observation

   Location characteristic will be observed in internal and external aspects (Fig. 4.8).
3. Analysis model development

In 2010, there were 14 variables had been analyzed with Multinomial Logit Model. The most important variables for railway were accessibility from origin and to destination. In 2011 and 2012, values of those accessibilities variable were explored. In 2011, survey on freight transport was done, but accessibility variables were excluded from the analysis as it is not problem to be researched for freight transport that very different variable compared to passenger transportation. Therefore, this research focuses on passengers transport.

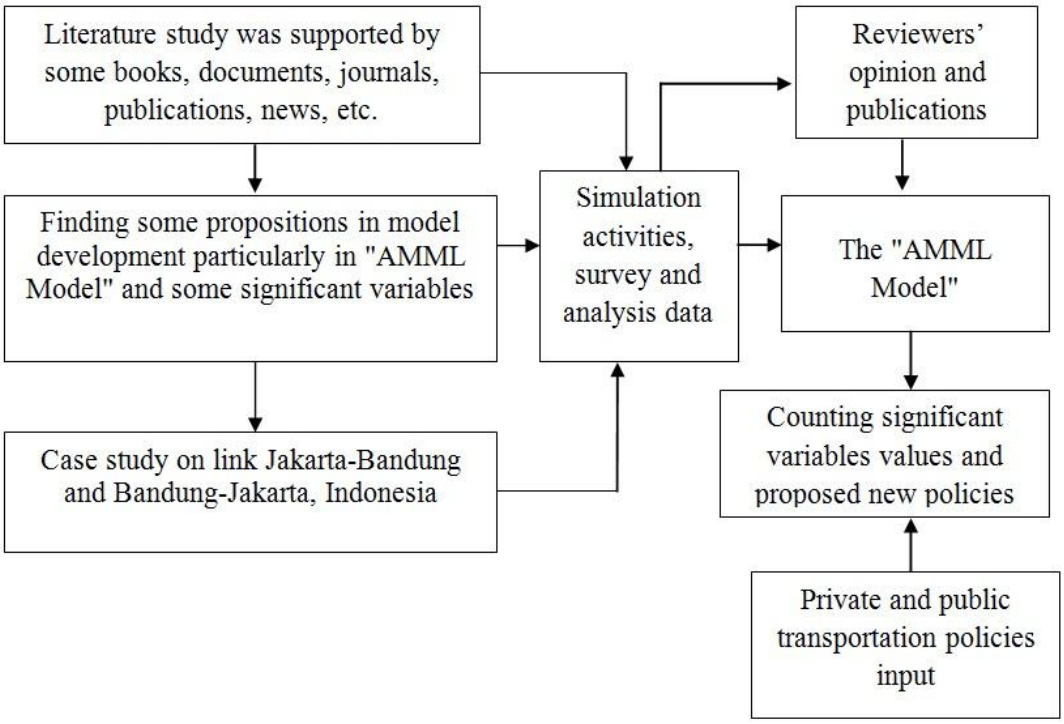


Figure 4.7 Literature Study and Detail Procedure

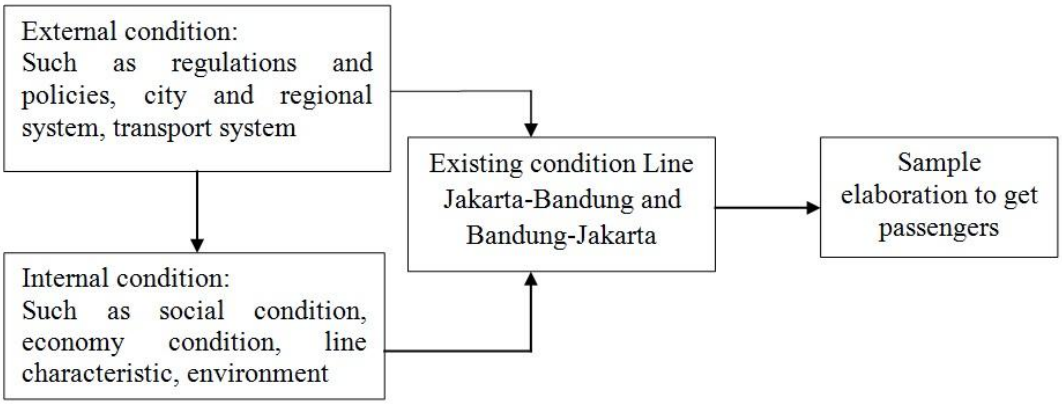


Figure 4.8 Location Characteristic Analysis

4. Study of passengers transportation for private and public transport policy in Indonesia

   In our previous researches, primary surveys have been done for the users of car, minibus, and train. Primary research surveys were done in 2010, 2011, 2012 and 2014. Those surveys were designed phase by phase as there were new variable should be analyzed. New equation keeps progressing as new variables being added in the model to analyze its values and its significance. After running the model, the research then develops recommendations to improve private and public transportation services.
5. The development of policy recommendation to improve private and public transport

   This research interpreted the results from data analysis using AMML Model which was applied on the direction Jakarta-Bandung and the direction Bandung-Jakarta into policy recommendation to improve private and public transport.

4.2. Intercity Transport between Jakarta and Bandung

Jakarta, as the capital city of Indonesia,has been a role model for other Indonesia cities. DKI Jakarta Government has a strong will to balance the environmental interests with social economic interests of the society within the sense of a sustainable development. The city transport policy encourages strategies to increase participation of the public and private transports and to prevent the environmental pollution as well as to intensify environmental management system.

Bandung, the Indonesian major city has strong relationship with Jakarta. Both cities are ±173km apart and are connected by railways and road through highland trace of Western Priangan (Fig. 4.9). Both road and railway routes mostly has similar horizontal alignment, thus have quite the same average travel time of about 3 hours (Fig. 4.10).

Figure 4.9 The Jakarta-Bandung Corridor

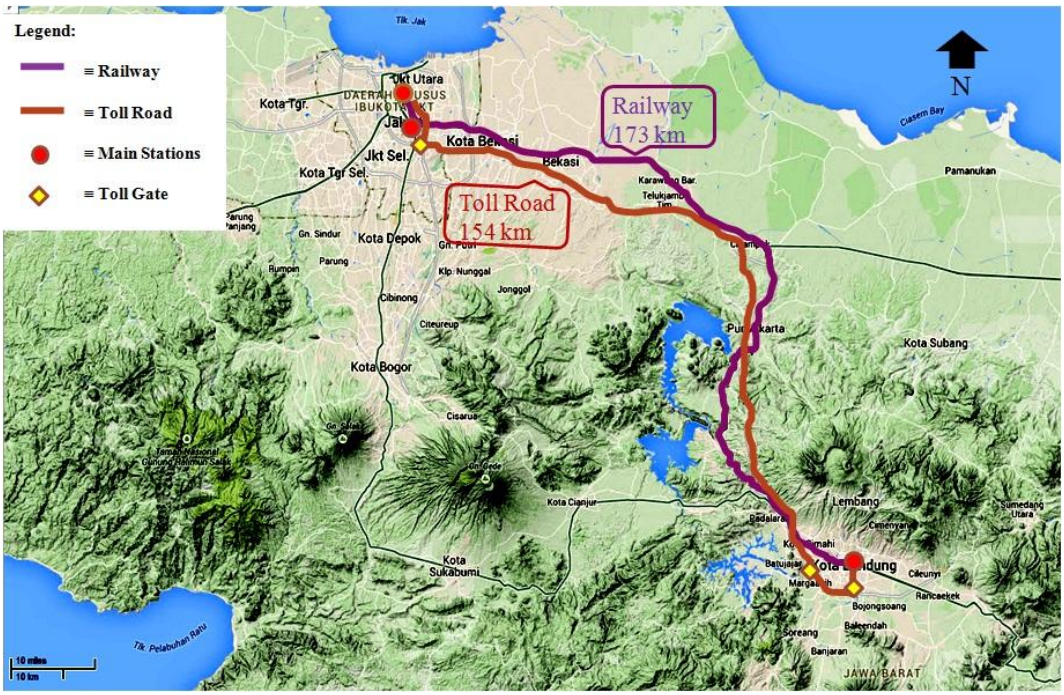
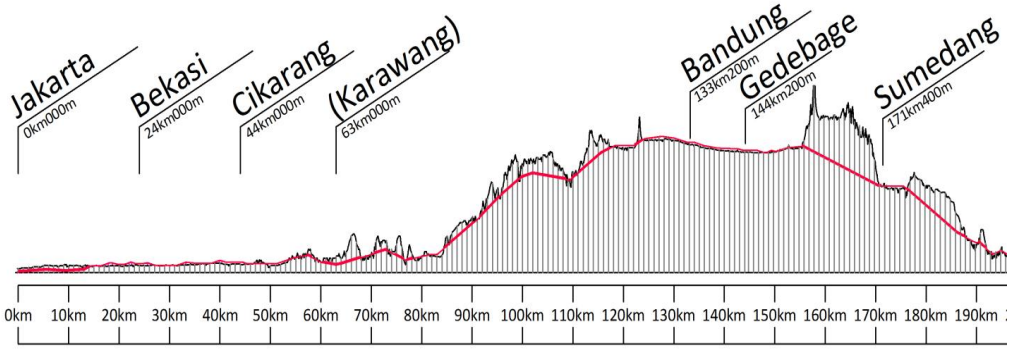


Figure 4.10 Railway and Road Transport on the Jakarta-Bandung Corridor

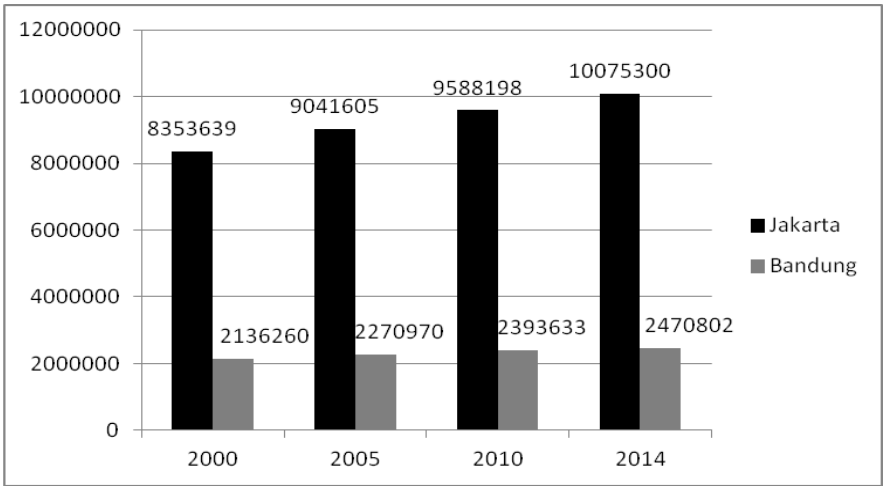
As the road and railway passing through mountainous geography, it has topographical challenges as can be seen in Fig. 4.11. Started at kilometer 90th from Jakarta, the railway starts to steeply increase.



Source: Dirjen Perkeretaapian

Figure 4.11 Profile of Line Jakarta-Bandung

Before 2010, the railway service cannot keep up with significant increasing transport demand. On Java Island the train share is decreasing by -0.9 % per year (Van der Ven, 2010). The situation for railway is very ironic, because its services are decaying due to decreasing demands. Statistic data of Jakarta and Bandung from 2000 to 2014 (BPS, 2014,) shows steady increase of population (Fig. 12). At 27 April 2010, after 39 years in serving PT. KAI discontinue Parahyangan Batavia train and only continue to operate Argo Gede Train, which was change to be Argo Parahyangan.



Source: BPS DKI Jakarta dan BPS Kota Bandung, 2015

Figure 4.12 Number of Population in Jakarta and Bandung

The Parahyangan Batavia train has been serving Jakarta-Bandung corridor since May 16th,1884. At that time, Jakarta-Bandung was a favorite line among the Dutch. It was because the railway track has a very beautiful scenery and cool air. In 1995, PT. Kereta Api Indonesia (Indonesian Railway Company) launched Argo Gede Train,to complement the Parahyangan Train. A decade after the government built the Cipularang toll road from Jakarta to Bandung, and immediately the Parahyangan occupancy rate only 50%. PT. KAI's effort to cut the tarif failed to regain passenger and causing a 36 billion IDR loss one year.

Generally in Indonesia, there are many railway lines operating in negative incomes and cannot cover infrastructure investment and rolling stock maintenance raw materials. Particularly in Java where 30% of railway lines are abandoned with critically condition. Therefore nowadays, there are many actions and policies are planned to improve railway conditions.

4.3. The Economic Affordability Analysis of Intercity Transport Modes

The existing Indonesian environmental laws and regulations show government commitment on environment protection, quality service improvement, and infrastructure investment in mass transportation system development. In regard to environmental aspect, that every development of mass transport system should pass environment impact. As for infrastructure investment, the Law No.22 of 2009 on traffic and road transport mandates that all major cities with over 500,000 populations should develop master plan to include mass transport system infrastructure and travel management system. Those policies encourage the development of railway services between two main cities, such as Jakarta and Bandung.

To be financially sustainable, as a mass transportation, train should meet the economic affordability of its potential riders. It is imperative to understand the paying capacity (affordability) of people against the services. This research

categorized such capacity into 4 income levels which are very low, low, medium, and high income. They will spend their money to pay the cost of travel depending to tariff classification and travel distance.

In Java, train service price is less competitive compare to other modes of land transport, such as car, minibus and bus. This situation can be better described from the losing demand of current train service. There are two cases to aforementioned problem. First, is "Jakarta – Bandung" trip which is short distance intercity travel with around 173km of distance. The train service is 200.000 IDR, the bus service is 50.000 IDR, the car is 300.000 IDR, and the minibus is 200.000 IDR (Jakarta-Bandung price of transports by mode, 2015). Second is "Jakarta – Surabaya" trip, which is long distance intercity travel with 1000 km of distance. The train service is IDR 1.200.000, the bus service is IDR 50.000, the car is IDR 2.662.200 and the minibus service is IDR 1.200.000 ("Jakarta-Surabaya" price of transports by mode, 2012). It was considered the prices of round-trip travels particularly for public transport it is in "Economic class" by different modes. From both case, bus has the lowest price over other modes. The average economic group of people accessing train service as their daily transportation is difficult (Table 4.1).

Table 4.1 Weight of the Transport Budget for Railway Travellers in Java

Economic Active Population 2011 Total = 171,206,108 hab	**Units**	**Income class**			
		High	**Medium**	**Low**	**Very Low**
Percentage of the Economic active population > 15 years old	[%]	20	40	28,87	11,13
Population by class of income	x 1000 [hab]	34241	68482	49427	19055
Average Salarie/month	[IDR]	6635000	4578000	2504000	800000
Tarifs for round trip at 200km. (1) Executive class (2)Business classe (3),(4) Economic	[IDR]	212130	121468	111696	111696
Transport budget/month in considering quotidian rail displacements for round trip between cities separated by 200 km (20 travels)	[IDR]	4242600	2429360	2233920	2233920
Weight of transport budget into the individual income per month	[%]	1060650	303670	386893	1003558
Weight of transport budget into the individual income per month	[%]	64	53	89	279

Sources: Barus et al., 2012

Currently, the price of train services in Java is perceived as very high for general population and particularly for the “income class” of travelers. Despite of prices segmentation in train service, it is still difficult for "Low" and “Very low” income to access train service. This condition means that train cannot be used as a daily mode choice by those people. The use of trains is to serve less than daily travel trip.

As a comparison, this research try to analyze what happen in France. It was different from the use of railway in France. It could serve daily travel trip. The economic accessibility of the traveler is good enough (Table 4.2), if the threshold of the "weight of transport budget" = 1/3 of income is respected. Prices of train service in France effectively allow most of population to access it.

Table 4.2 Weight of the Transport Budget for Train Travellers in France

Economic Active Population 2011 Total = 28,390,000 hab	**Units**	**Income class**			
		High	**Medium**	**Low**	**Very Low**
Percentage of the Economic active population > 18 years old	[%]	20	50	30	30
Population by class of income	x 1000 [hab]	5678	14195	8517	8517
Average Salarie/month	[€]	5085	1937	1271	1000
Tarifs for round trip at 200km. (1) First class (2)Second classe (3) Students & Low income workers	[€]	50	33	18	18
Transport budget/month in considering quotidian rail displacements for round trip between cities separated by 200 km (20 travels)	[€]	1000	660	360	360
Weight of transport budget into the individual income per month	[%]	20	34	28	36

Sources: Barus et al., 2012

For the daily travels between cities, with the distance around 173 km, the railway is not "competitive" with car, minibus and bus. And even for the long distance travels in Java the train is “little competitive". It was known that train in current situation cannot be used as a daily mode for traveling. It also cannot compare to the bus service. It might be bus as the mode which can be as the daily mode for travelling. In conclusion, bus as a mode which can be functioned as a mass transport more than train. Then if this research will continue to research the competition, it should exclude bus as mode in comparison. Train cannot compete

to bus, beside it has different segment market and also different characteristic where bus has not fixed stop. Train could compete with minibus, and private car on the Jakarta-Bandung corridor.

Figure 4.13 Price Structure of Railway Comparison between PT. KAI and SNCF

4.4. Evolution of Ideas about the Modal Competition

In exploring intercity transportation on the Jakarta-Bandung corridor, the research did a field survey. Data collection is started by collecting secondary data, such as reports, books, maps, articles, papers, and studies by PT. KAI, ministry of transportation, cities' survey and some train projects. These data were very useful, however primary data are still needed to be collected (Fig.4.14). Therefore, this research took primary data from survey questionnaires and visual observations.

Questionnaire surveys were taken 4 times, in 2010, 2011, 2012 and 2014. Each year, questionnaires were distributed with respect to the survey and data collection methodology. The survey was designed in sequential basis in which the preceding survey will provide basis for the following survey for refinement and sophistication. The first survey was designed with certain problem definition and the results analysis becomes an input to the second survey. The second survey

result inspired the third survey, and the third survey results analysis will be completed by the forth survey as the final stage of research analysis.

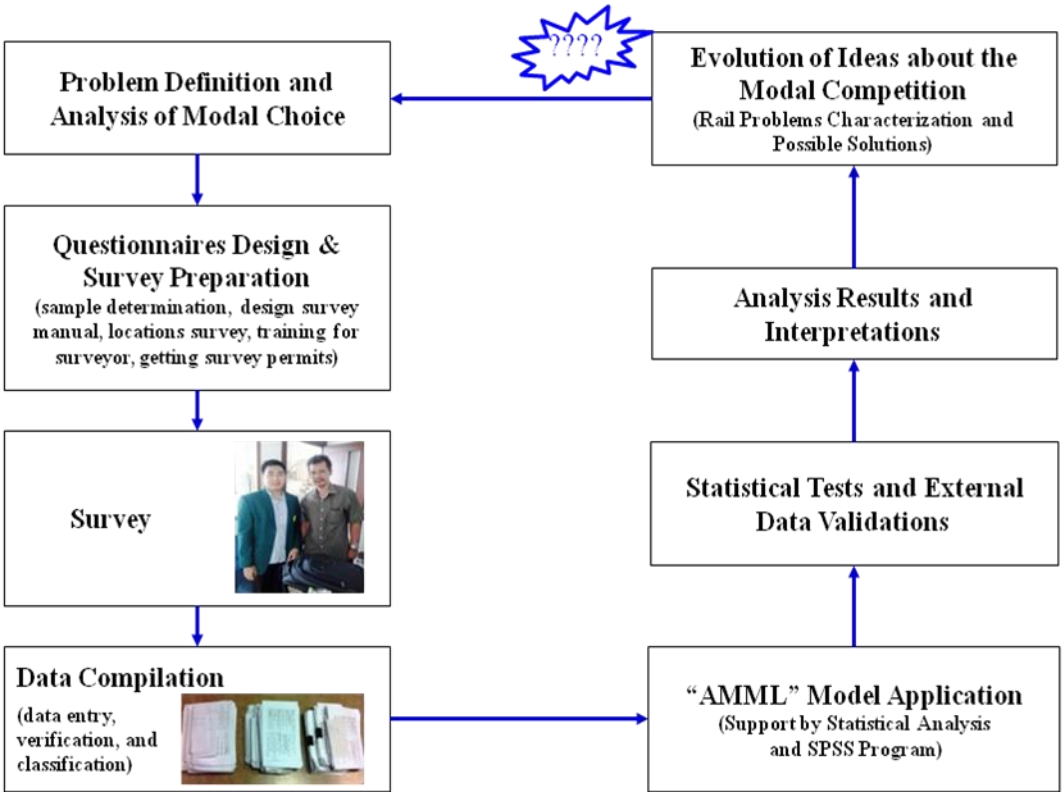


Figure 4.14 Method of Collection Data by Survey and Process of Getting the New Approach

In year 2010, questionnaires were distributed to 300 respondents from railway, minibus, and private car passengers. Each 100 questionnaires were distributed at rest area, pole minibus, and rail station (see Table 4.3). The data analysis of survey results indicated 5 main problem variables, particularly accessibility (Barus et all, 2011).

In the modal competition on the Jakarta-Bandung corridor, people consider as high priority to improve accessibility to destination, accessibility from home and security. Obviously, public transport does not have "door-to-door" service, so connection between other modes of transport as a combined mode is necessary for its passengers.

Table 4.3 Data Collection through 4 Types Questionnaires

No	Survey (Year)	Field Application	Number of Respondents	Objectives	Interpretation Results
1.	2010	Rail station, minibus pole, rest area for toll gate information	Total 300 questionnaires, each location 100 questionnaires	Preferences at intercity transportation Jakarta-Bandung (Modal Node1 to Modal Node 2	Significant variables: accessibility to destination and accessibility from origin, and safety
2.	2011	Rail station, minibus pole, rest area for toll gate information	Total 180 questionnaire s, each location 60 questionnaires, each passengers gave their opinion for 3 modes	• Preferences at intercity transportation Jakarta-Bandung (Modal Node 1 to Modal Node2) • Variables accessibility to destination and accessibility from origin were changed into only variable accessibility. • Additional questions for derivatives variables of accessibility	No additional variable is significant
3.	2012	Rail station, minibus pole, rest area for toll gate information	Total 180 questionnaires, each location 60 questionnaires, each passengers gave their opinion for 3 modes	• The same questionnaire with data collection in 2011. • To add the number of questionnaires for data collection 2011	No additional variable is significant
4.	2014	Rail station, minibus pole, rest area for toll gate information	Total 900 questionnaire, each location 300 questionnaires	Preferences of variable accessibility was translated to variables at intracity transport at origin and at destination (Origin-Modal Node 1-Modal Node 2-Destination)	Find some additional significant variables and valid by statistic tests and statistical external validation

In particular to analysis for railway competitiveness over the other modes, variable of accessibility to destination is more important than accessibility from home because people are generally familiar with their immediate surroundings and transportation option proximity to their home. It would be difficult to take any risk if they didn't know the environment around their destination. Thus, if accessibility to the rail station is not adequate and involve some uncertainty in transferring from one transport mode to another, people will not feel safe to travel to their desire location.

In year 2011, the research distributed 180 questionnaires to capture 3 opinions of train, minibus and private car passengers. It took place in rest area, pole minibus, and rail station along Jakarta-Bandung corridor. There were also 93 questionnaires with 186 of freight forwarders/shippers preferences in transporting their freight from Jakarta to Surabaya. The survey showed different problem between passengers and freight. The accessibility is the main problem of passenger transportation but not for the freight. Therefore, this research focuses on passengers transport. However on passenger's preference survey, it was found that there were not any additional significant variables.

In year 2012, the same type of survey in 2011 was done to add additional data, but the results were the same, and then the proposed model was changed. The idea turned to use the "AMML Model". The accessibility from home variable was changed to be intracity variables at origin and accessibility to destination variable was changed to be intracity variables at destination.

Table 4.4 Modal Choice Variables

	Survey 2010	Survey 2011 and 2012	Servey 2014
I)	**Quality services variables of intercity modes:** V_1 ≡ Amenities ($V_1 = 0$, this factor is indirectly considered by V_6) V_2 ≡ Punctuality V_3 ≡ Operator's Reliability V_4 ≡ Facilities (Toilet, Air Condition, Television, Comfortable Seat) V_5 ≡ Frequencies V_6 ≡ Services (Food, Drink, Gift, Promotion); V_7 ≡ Quality/Price (traveler perception of global service for money) V_8 ≡ Accessibility from home V_9 ≡ Accessibility to destination V_{10} ≡ Security and Safety V_{11} ≡ Natural scenery V_{12} ≡ Cleanliness V_{13} ≡ Image (Prestige, Modal Service Perception) V_{14} ≡ Travel time ($V_{14} = 0$, we exclude this factor of analysis because the travel time is almost the same for the 3 modes of transport and provoke a diminution of the discrimination for the rest of variables. *Travel Time* $\Delta MAX = 0.09$	**Quality service variables of intercity modes:** V_1 ≡ Amenities V_2 ≡ Punctuality V_3 ≡ Operator's Reliability V_4 ≡ Facilities V_5 ≡ Frequencies V_6 ≡ Security V_7 ≡ Quality/Price V_8 ≡ Mode Reliability V_9 ≡ Accessibility V_{10} ≡ Safety V_{11} ≡ Natural scenery V_{12} ≡ Cleanliness V_{13} ≡ Image (Prestige) V_{14} ≡ Duration **We added derivative variables for quality services of intracity modes:** VA_1 ≡ Vehicle condition VA_4 ≡ Duration VA_2 ≡ Information VA_5 ≡ Cost VA_3 ≡ frequency VA_6 ≡ Safety	**Quality service variables on total transport chain:** **A. Intracity Variables at Origin** (is evaluated from V_8) VIO_1 ≡ Travel time VIO_2 ≡ Cost VIO_3 ≡ Safety VIO_4 ≡ Information availability VIO_5 ≡ Connection **B. Intercity Variables:** VM_1 ≡ Travel time VM_2 ≡ Cost VM_3 ≡ Safety VM_4 ≡ Information availability **C. Intracity Variables at Destination** (is evaluated from V_9) VID_1 ≡ Travel time VID_2 ≡ Cost VID_3 ≡ Safety VID_4 ≡ Information availability VID_5 ≡ Connection
II)	**Main Variables Results:** Accessibility to destination (V_9), Accessibility from home (V_8), and Security and Safety (V_{10})	**Main Variables Results:** After analysis , there is not any new additional significant variables for intercity mode choice. We abandoned the derivatives variables.	**Main Variables Results:** Found that there are several additional significant variables in each link. They have been validated by statistical tests, and confirmed by external data

4.5. Analysis Data on the Corridor Jakarta-Bandung

This research applied "the AMML Model" with questionnaires distribution on year 2014 in the case study of Jakarta-Bandung corridor (Annex). Passengers' background from the samples showed that there are some different conditions between the direction Jakarta-Bandung and the direction Bandung-Jakarta.

4.5.1 Respondents' Profile on Direction Jakarta-Bandung

A. Respondents' Origin and Destination on the Jakarta-Bandung Direction

The biggest percentage of railway passengers' from Jakarta origin is from the Central Jakarta (28.13%), while the lowest percentage is from Western Jakarta (15.63%). The destination area at Bandung, the most favorable is the centre (39.58%) and the lowest is to go to the west (10.42%).

For minibus passengers' distribution, they were mostly also from Central Jakarta (62.50%), while the lowest were from Northern Jakarta (2.08%). As for the destination area in Bandung, they preferred Northern Bandung (42.71%) and least preferred Southern Bandung (7.2%).

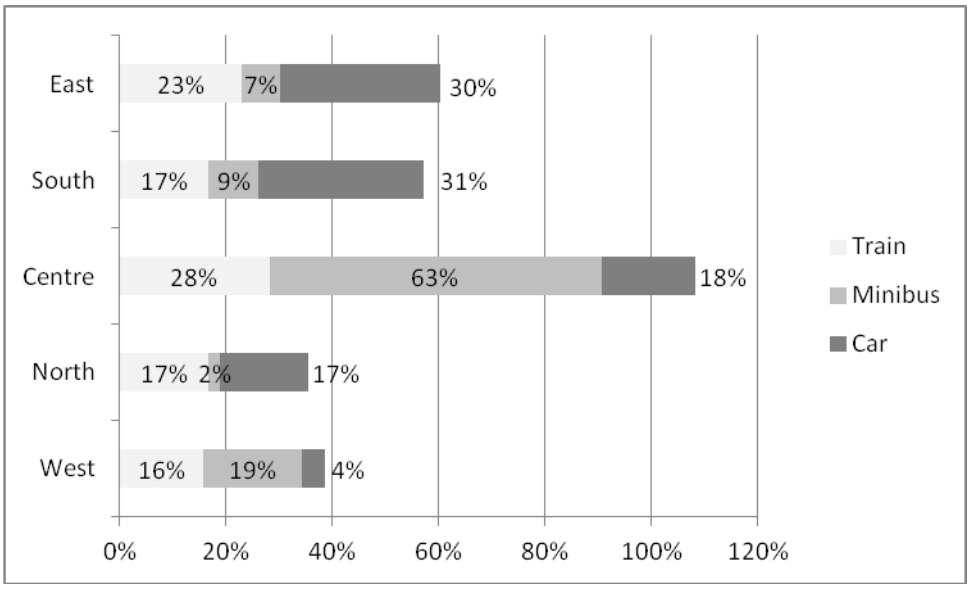


Figure 4.15 Jakarta Zones as Origin for Train, Minibus and Car Passengers

The study results for car's passengers have different distribution of origin from railway's and minibus's passengers'. Southern Jakarta is the highest origin of car passengers (31.25%) while Northern Jakarta is the least origin (4.17%) which similar to train's and minibus's passengers. As for the destination area of car's

passengers in Bandung, Northern Bandung is the most preferred destination (33.33%), but it has the same lowest preferred place as with railway's passengers, which is Western Bandung (13.54%).

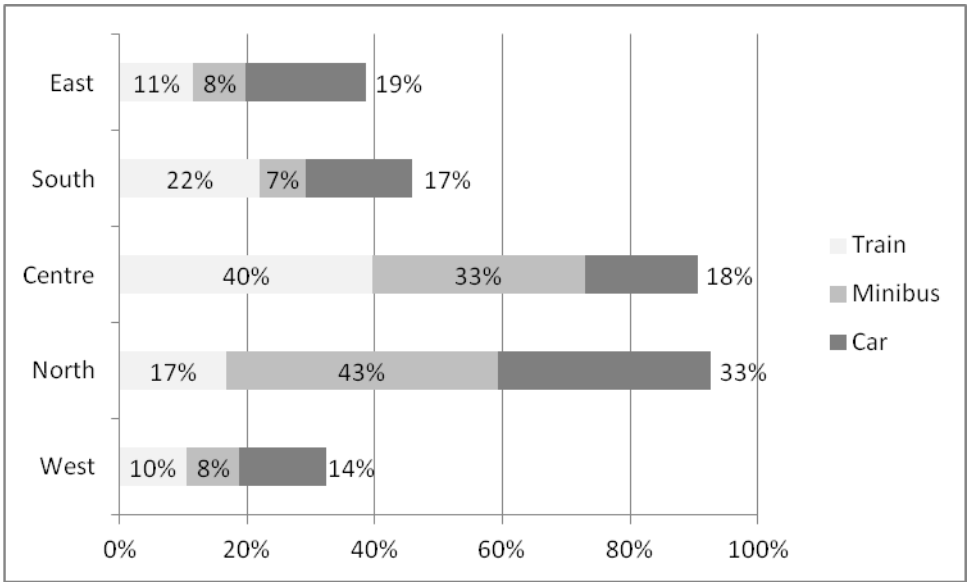


Figure 4.16 Bandung Zones as Destination for Train, Minibus and Car Passengers

B. Evolution of Travel Time and Cost for Intercity Transport Services on the Jakarta-Bandung Direction

According to data year 2008, airplane still serves this corridor, but due to the competition among modes and it cannot get its required demand, and then its operation was terminated. Travel time for train is the highest compare with air plane, minibus and car. Train cost was fluctuated because of the subsidies from the government. Nowadays, in this direction to go with car is the most expensive cost.

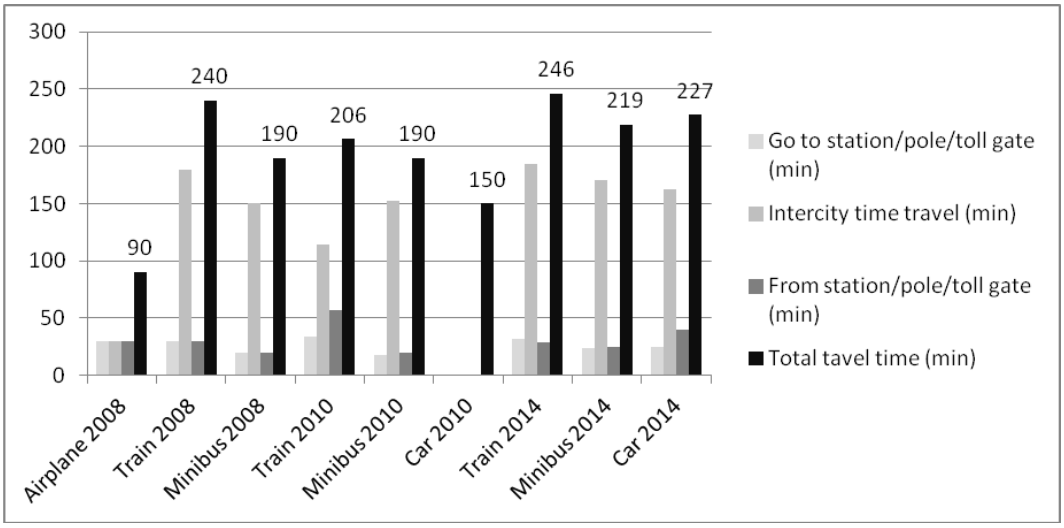


Figure 4.17 Travel Time in Catching Air Plane, Train, Mini Bus and Car from year 2008, 2010, and 2014

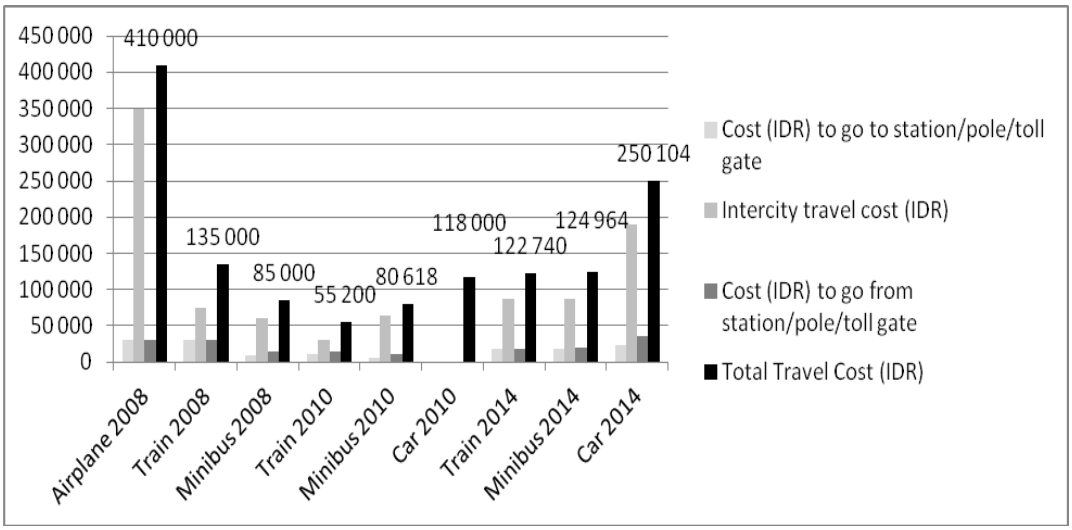


Figure 4.18 Cost of Using Air Plane, Train, Mini Bus and Car from year 2008, 2010, and 2014

4.5.2 Respondents' Profile on the direction Bandung-Jakarta

The second case study is on the direction Bandung-Jakarta. In this case, passengers' origin is Bandung and their destination is Jakarta. Passengers' characteristics who live in Bandung are not the same with passengers' who live in Jakarta in using this corridor.

A. Respondents' Origin and Destination

Almost the same of railway passengers' distribution of origin in Jakarta, the biggest percentage of origin in Bandung is the centre (train 36%, minibus 16%, and car 35%) and the lowest is from the east (train 11%, minibus 18%, and car 7%). And also for the destination area at Jakarta, the most preferable is the centre (train 29%, minibus 48%, and car 26%) and the lowest is to go to the west (train 11.44%, minibus 26%, and car 8%).

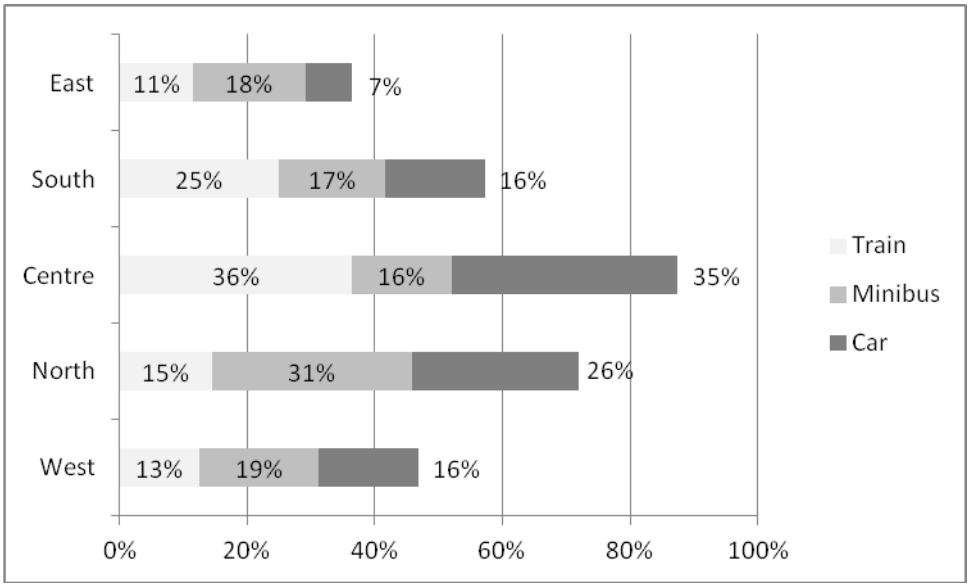


Figure 4.19 Bandung Zones as Origin for Train, Minibus and Car Passengers

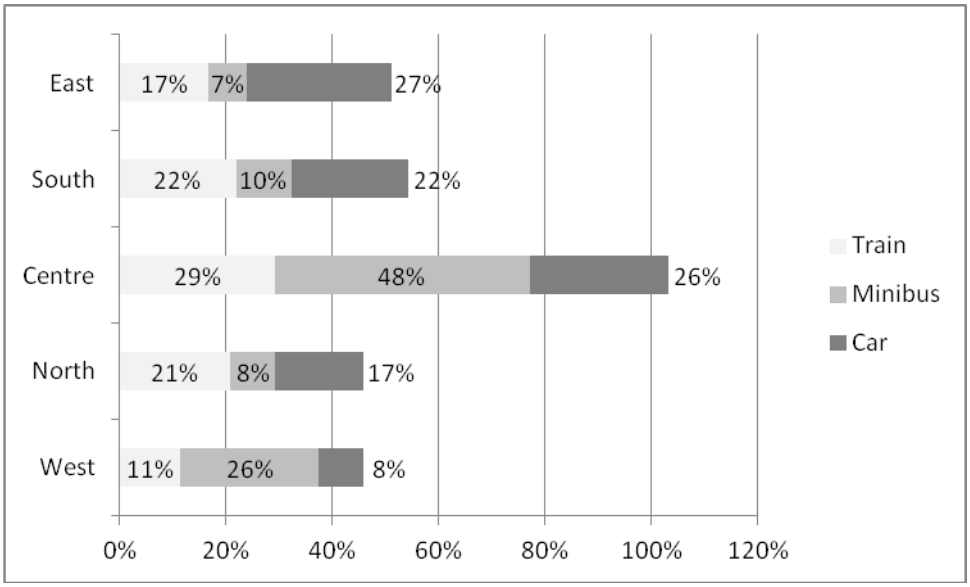


Figure 4.20 Jakarta Zones as Destination for Train, Minibus and Car Passengers

B. Travel Time and Cost for Intercity Transport Services on the Bandung-Jakarta Direction

In survey year 2014, it was collected data of travel time and cost from this direction. Because of the different passengers' characteristic, then the value for this direction is different. The highest travel time and cost was train. The lowest travel time was car. The lowest cost was minibus.

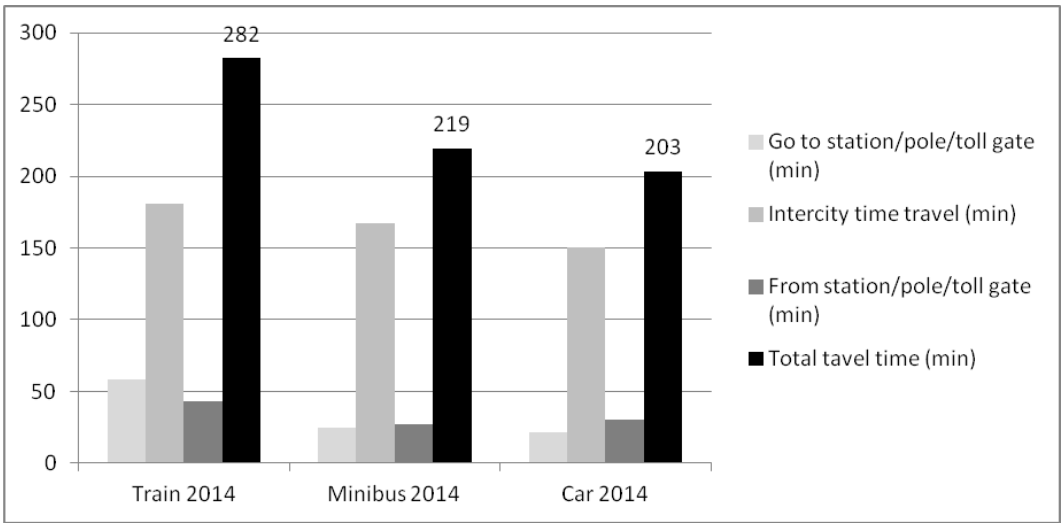


Figure 4.21 Travel Time in Catching Train, Mini Bus and Car year 2014

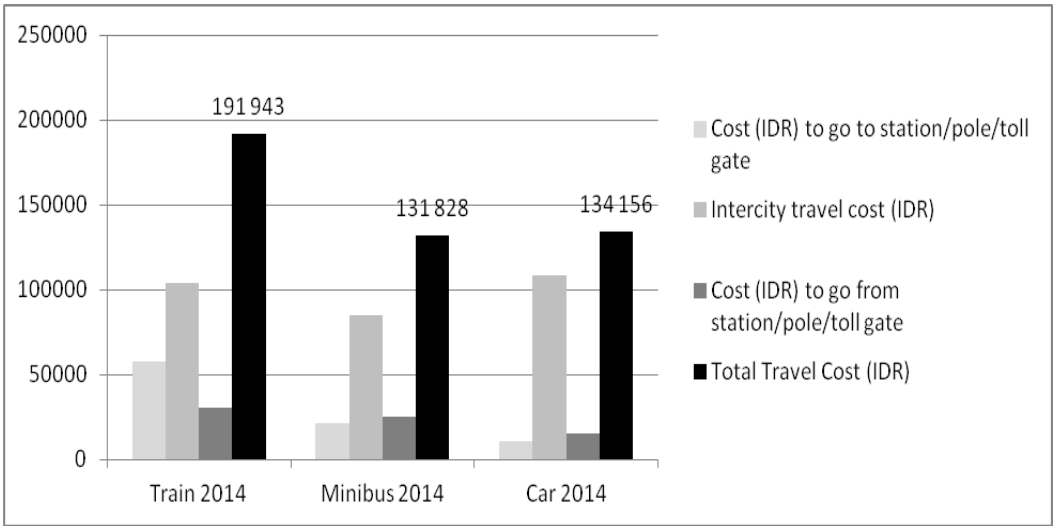


Figure 4.22 Cost of Using Train, Mini Bus and Car year 2014

4.6. Modal Competition of Corridor

4.6.1 Variables' Coefficients Values in Utility Function

Utility value was used to measure the degree of satisfaction obtained by a choosing one mode of intercity transport. This utility value depends on individual factors of each type of transport service. In this research, a representative passenger was assumed for all traveler purposes (business/worker, student, doing personal or familial matter and leisure) to choose the intercity mode to travel yielding the highest utility. Utility function is usually expressed as a linear number of independent variables affected by β factors. This approach assumes that the socio-economic factors greatly affect the modal choice process. There are three important utility functions to observe:

1. Utility Function of intracity transport at departure city
2. Utility Function of intracity transport at arrival city
3. Utility Function of intercity modes

Independent variables or "choice factors" that we observed for intracity transport at departure city were total transport time from home to modal node 1 (VIO1), cost from home to modal node 1 (VIO2), safety condition from home to modal node 1 (VIO3), information available from home to modal node 1 (VIO4), connection condition from home to modal node 1 (VIO5). For intracity transport at arrival city, we observed total transport time from modal node 2 to arrival city (VID1), cost from modal node 2 to arrival city (VID2), safety condition from modal node 2 to arrival city (VID3), information available from modal node 2 to arrival city (VID4), connection condition from modal node 2 to arrival city (VID5). Considerations of intercity modes service variables were total transport time from modal node 1 to modal node 2 (VM1), cost from modal node 1 to modal node 2 (VM2), safety condition from modal node 1 to modal node 2 (VM3), information available from modal node 1 to modal node 2 (VM4), The results show the utility of improvements for each factor of the intercity modes on

the direction Jakarta-Bandung to gain in competitiveness according to passengers preferences.

Each individual respondent will make decision base on several types of options. This research will identify the most influential variable in any decision made. This approach could also provide an overview of the variables which is relatively important to the socio-economic characteristics that in turn can influence policy making process. Discrete choice questionnaire will be translated into ordinal and nominal data with the size of Likert scale. The ordinal measurement was used by asking respondent to fill by making cross (x) in one of the choices in the questionnaires. The associated with variables scaling from 1 to 4 (ordinal data) that reflect Likert scale as the following conditions:

1 = not good

2 = less good

3 = good

4 = very good

The comparative reference value is 0, it represents the “private car” mode preferences. When factors are positive for “minibus” or “train”, it means that users have current preferences for “car”. Positive coefficients for “minibus” and “train” mean that the correspondent variables are the most important factors to improve their own competitiveness. When factors are negative for “minibus” or “train”, it means that users have current preferences them over the factors of “car”. So, negative coefficients for “minibus” and “train” mean that the correspondent factors do not need to be improved, they represent their current strengths.

A. Direction Jakarta-Bandung

The application of "AMML" model based on our distribution value sample (Ben Ben-Akiva, 1985) on the Jakarta-Bandung corridor let us to obtain the utility values of modes in competition. The analysis of these functions and their

respective parameters in using 288 questionnaires was found the coefficients of each variable with car as reference.

For intracity transport at Jakarta as origin data was compiled to fill the Table 3.16 and by using equation 3.16 the model results are:

$U_{\text{go to rail station}} = 9.166 + 0.337VIO_1 - 0.205VIO_2 - 0.759VIO_3 + 0.704VIO_4 - 1.548VIO_5$……..(4.3)

$U_{\text{go to minibus pole}} = 4.535 + 0.994VIO_1 - 0.697VIO_2 - 0.769VIO_3 + 0.017VIO_4 - 0.367VIO_5$.....(4.4)

$U_{\text{go to highway toll gate}}$ is reference = 0

Where:

$VIO_1 \equiv$ travel time

$VIO_2 \equiv$ cost

$VIO_3 \equiv$ safety

$VIO_4 \equiv$ information

$VIO_5 \equiv$ connection

Our results were statistically tested using some indicators, such as the index value of the likelihood ratio (rho-squared = ρ^2). ρ^2 is in the range 0 to 1. Rho squared (ρ^2) value is similar to r^2 in linear regression. An index likelihood ratio ρ^2 interval between 0.2 and 0.4 indicates the relevance of the data and can be compared to the value of r^2 of the linear regression interval 0.5 to 0.8. In our case ρ^2 is found relevant indicating that the data is excellent (Table 4.5). Chi-square test is used to check the accuracy of models. In our case, χ^2 count > χ^2 table. So the resulting model can be used to predict the value of the dependent function (Table 4.6)

Table 4.5 ρ^2 value for the JBO data

Cox and Snell	0.280
Nagelkerke	0.315
McFadden	0.150

Table 4.6 Model Fitting Test JBO

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	Df	Sig.
Intercept	371.051	14.581	2	.001
VIO_1	381.678	25.209	2	.000
VIO_2	375.186	18.716	2	.000
VIO_3	371.869	15.400	2	.000
VIO_4	367.259	10.790	2	.005
VIO_5	396.602	40.133	2	.000

For intracity transport at Bandung as destination data was compiled to fill the Table 3.17 and by using equation 3.19 the model results are:

$U_{\text{from rail station}} = -6.288 + 0.425V_1 + 0.115V_2 - 0.807V_3 + 0.425V_4 + 0.795V_5$…….(4.5)

$U_{\text{from minibus pole}} = -14.307 + 0.654V_1 + 0.003V_2 - 0.620V_3 + 0.442V_4 + 1.715V_5$...(4.6)

$U_{\text{go from highway toll gate}}$ is reference = 0

Where:

$VID_1 \equiv$ travel time

$VID_2 \equiv$ cost

$VID_3 \equiv$ safety

$VID_4 \equiv$ information

$VID_5 \equiv$ connection

Table 4.7 ρ^2 value for the JBD data

Cox and Snell	0.271
Nagelkerke	0.305
McFadden	0.144

Table 4.8 Model Fitting Test JBD

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	416.900	43.619	2	.000
VID_1	392.612	19.331	2	.000
VID_2	374.237	.956	2	.620
VID_3	383.774	10.492	2	.005
VID_4	376.143	2.861	2	.239
VID_5	408.987	35.706	2	.000

For intercity transport modes which serve the direction Jakarta-Bandung data was compiled to fill the Table 3.18 and by using equation 3.21, the model results are:

$U_{train} = 4.010 - 0.672V_1 + 0V_2 + 0.342V_3 - 0.539V_4$ …….……...…...…(4.7)

$U_{minibus} = 2.231 - 0.193V_1 + 0V_2 + 0.337V_3 - 0.556V_4$ ….……...…(4.8)

U_{car} is reference = 0

Where:

$VM_1 \equiv$ travel time

$VM_2 \equiv$ cost

$VM_3 \equiv$ safety

$VM_4 \equiv$ information

Table 4.9 ρ^2 value for the JBI data

Cox and Snell	0.133
Nagelkerke	0.150
McFadden	0.065

Table 4.10 Model Fitting Test JBI

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	117.686	5.605	2	.061
VM_1	148.737	36.656	2	.000
VM_3	113.457	1.376	2	.503
VM_4	116.105	4.024	2	.134

B. Direction Bandung-Jakarta

The analysis of utility functions and their respective parameters was showed again in the same approach in using 288 questionnaires.

For intracity transport at Bandung as origin data was compiled to fill the Table 3.16 and by using equation 3.16 the model results are:

$U_{\text{go to rail station}} = 23.260 - 0.765V_1 - 2.227V_2 + 0.547V_3 - 0.624V_4 + 0V_5$ …..(4.9)

$U_{\text{go to minibus pole}} = 17.205 - 0.060V_1 - 2.238V_2 + 0.338V_3 - 0.192\ V_4 + 0V_5$ …..(4.10)

$U_{\text{go to highway toll gate}}$ is reference = 0

Where:

$VIO_1 \equiv$ travel time

$VIO_2 \equiv$ cost

$VIO_3 \equiv$ safety

$VIO_4 \equiv$ information

$VIO_5 \equiv$ connection

Table 4.11 ρ^2 value BJO

Cox and Snell	.231
Nagelkerke	.259
McFadden	.119

Table 4.12 Model Fitting Test BJO

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	232.135	43.563	2	.000
BJSO	190.428	1.856	2	.395
BJIO	190.631	2.059	2	.357
BJTTO	210.897	22.324	2	.000
BJPRO	213.453	24.880	2	.000

For intracity transport at Jakarta as arrival city data was compiled to fill the Table 3.17 and by using equation 3.19, the model results are:

$U_{\text{from rail station}} = 25.410 - 0.331V_1 - 1.446V_2 + 0.900V_3 - 0.618V_4 - 2.086V_5$……(4.11)

$U_{\text{from minibus pole}} = 14.938 + 0.405V_1 - 1.441V_2 + 0.316V_3 - 0.339V_4 - 0.957V_5$.....(4.12)

$U_{\text{from highway toll gate}}$ is reference = 0

Where:

VID_1 ≡ travel time

VID_2 ≡ cost

VID_3 ≡ safety

VID_4 ≡ information

VID_5 ≡ connection

Table 4.13 ρ^2 value BJD

Cox and Snell	.360
Nagelkerke	.405
McFadden	.203

Table 4.14 Model Fitting Test BJD

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	372.950	62.971	2	.000
BJTTD	333.494	23.516	2	.000
BJPRD	354.002	44.024	2	.000
BJSD	315.996	6.017	2	.049
BJID	312.576	2.597	2	.273
BJCD	345.164	35.185	2	.000

For intercity transport modes which serve the direction Bandung-Jakarta data was compiled to fill the Table 3.18 and by using equation 3.21, the model results are:

$U_{train} = -22.598 + 0V_1 + 0.762V_2 + 1.669V_3 + 1.238V_4$ ……(4.13)

$U_{minibus} = -23.5631 + 0V_1 + 0.077V_2 + 0.871V_3 + 1.841V_4$ …..……..…..(4.14)

U_{car} is reference = 0

Where:

VI_1 ≡ travel time

VI_2 ≡ cost

VI_3 ≡ safety

VI_4 ≡ information

Table 4.15 ρ^2 value BJI

Cox and Snell	.263
Nagelkerke	.296
McFadden	.139

Table 4.16 Model Fitting Test BJI

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	Df	Sig.
Intercept	179.602	79.677	2	.000
BJPRI	120.808	20.883	2	.000
BJSI	109.889	9.965	2	.007
BJII	123.797	23.873	2	.000

4.6.2 Modal Choices

The analysis of strengths and weaknesses of train and minibus against car on the Jakarta-Bandung corridor based on user's preferences reveals the importance of each factor by intracity transport at both cities and modes quality services into the modal competition. These factors and their comparison among other intracity transports condition and other modes in a homogeneous way let us to understand the preferences and dislikes of transport users of each intercity mode. Then, based on the showed results, we expose our qualitative analysis of modal competition or "interpretation of results" which try to explain as better as possible the mechanism of users' choice in order to propose improvements to increase demand for the railways service.

The train service and minibus have not door-to-door service, so connections between other modes of transport in the city to both of them are necessary for their passengers. Private car has "door-to-door service", but in travelling from one city to another, it has to face intracity transport at departure city before travelling in intercity road and then when it has arrived at the arrival city it has to go thru the intracity transport there. As we mentioned previously, the answers of passengers about their travel concerning their total transport or "door-to-door", so we can say that all of them could get advantage or disadvantage into the modal competition by cause of their complementary modal relationships into the cities (intracity transport at departure city to intercity modes services between cities to intracity transport at arrival city).

Decision process in choosing intercity mode is begun by calculation of choices in influence of intracity transports, than choice of intercity mode. The final choice is calculated by "AMML" Model.

A. Direction Jakarta-Bandung

A.1 Intercity Modal Choice in Considering Intracity Transport

By using eq. 3.18 in chapter 3, choice of train which is influenced by intracity transport of Jakarta has the first level and minibus. The last is car. Rail station is located in the center of Jakarta, so relatively it has a good accessibility to reach. Although there are several minibus pole in Jakarta to give more access to the passengers but it is not enough. The most difficult to access is the highway toll gate, because the traffic jam in Jakarta City is significant, even though they are already in the city toll road, there is no guaranty to free from the congestion. The highway toll gate is located at the east of Jakarta.

Table 4.17 Modal Choice in Intracity Transport at Jakarta

Intracity Jakarta Link	Values	Choice I
Go to rail station	0.4000	I
Go to minibus pole	0.4000	I
Go to highway toll gate	0,2000	II

After they consider of intracity transport surrounding them, then they consider intracity transport around the destination location. By using eq.3.20, for railway, intracity transport at Bandung is the constraint. It has only the second position after minibus. The third is car. Minibus pole in several locations at Bandung is enough to give the good access to their passengers. The same situation at Jakarta, car has similar problem in Bandung. Highway toll gate is located at the west and the south of Bandung.

Table 4.18 Modal Choice in Intracity Transport at Bandung

Intracity Bandung Link	Values	Choice II
From rail station	0.3100	II
From minibus pole	0.5000	I
From highway toll gate	0.1900	III

By using eq. 3.22, services that have been given by train are good enough. It already reaches the first level than other modes. The second is minibus, the third is car. It means, even though there are several quality variables have to improve for train, but in modal competition, it cannot reach the best services.

Table 4.19 Modal Choice in Intercity Link

Intercity link	Values	Choice III
Train	0.4200	I
Minibus	0.3000	II
Car	0.2800	III

In reality condition at total passenger transport chain, the offered services of each mode are not enough, because train is not the first choice as intercity transport mode. We use "AMML" Model to prove which one is the best in modal competition on this link (eq. 3.31).

Table 4.20 Modal Choice in Total Passengers Transport Chain

Intercity Modal competition	Values	Choice Final
Train	0.4241	II
Minibus	0.4893	I
Car	0.0846	III

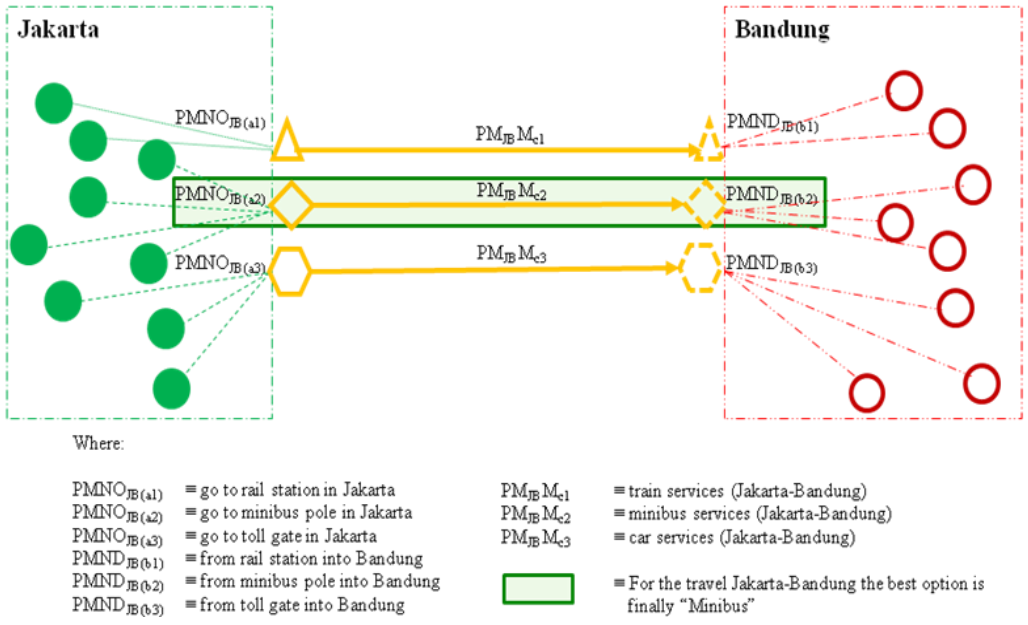


Figure 4.23 Choices from Jakarta to Bandung will be inclined to Minibus

For the case of minibus, it could take advantages of train and car difficulties in intracity transports, and then it can be the most competitive mode in total passengers transport on the direction Jakarta-Bandung. According to the passengers, the cost for train, minibus, and car is the same level, but both modes are penalized by their intracity transport condition. Simply, the relationship possibilities near rail stations at Bandung can penalize train as the first choice. That means too, a possible opportunity to increase the attractiveness of train by improving the intracity transport at Bandung.

In other words, any improvement of intracity transport relationships in the future both Jakarta and Bandung will perform the railway service too. If we improve the intracity transport of public transport as the bus, or if we create new mass transport networks into cities as “high level service bus”, “tramways” or “underground lines” the interurban railway transport will indirectly beneficiary. Unfortunately, the promotion of best local transports connections is out of the competence of "Kereta API". This kind of improvements has to be done by the establishment of a partnership between the Railway Company, the cities' transport authorities and the local companies of transports.

For the internal solutions, the budget of investment may be the first constraint. But in any case the suggested improvements do not represent important amounts in comparison with the damages that a continuity of loss of demand may provoke. The next step is the evaluation of “improvements safety condition”. It could realize by supporting all kind of facilities that passengers can feel save in travelling with. At least it is the less expensive improvements in the short term.

A.2 Validation Results

By using split half method, a half of data was used (after verification there are 165 questionnaires) to validate the choice results with the equation 3.31. The validation results showed that minibus is confirmed as the most competitive mode over the others (Table 4.21). The differences between two survey results are not significant (0-14%). This identification will permit to do formulate the most pertinent recommendations in order to improve the quality of a transport mode and make it advance into the modal competition.

The final result could be calculated with the other equation of the AMML Model (eq. 3.48). The validation of the second calculation is confirmed again that minibus has the highest opportunity (Table 4.22).

B. Direction Bandung-Jakarta

B.1 Intercity Modal Choice in Considering Intracity Transport

By using eq. 3.18, choice of railway is supported by intracity transport of Bandung. It has the first level. The second is minibus and the third is car. Rail station is located in the center of Bandung, so relatively it has a good accessibility to reach. The most difficult to access is the highway toll gate, because the traffic jam in Bandung City is significant, too. The highway toll gate is located at the west and the south of Bandung.

Table 4.21 External Validation o f Final Modal Choice in Intracity Mode Jakarta-Bandung

Model Validation Statistic (External Data)										
Jakarta Intracity Link			Bandung Intracity Link			Intercity Transport			Intercity Modal Competition		
Link 1	Probability of Choice	Choice	Link 2	Probability of Choice	Choice	Modes	Probability of Choice	Choice	Modes	Conditional Probability of Choice	Final Choice
Home to rail station	0.3900	II	Rail station to destination	0.3900	I	Train	0.3400	II	Train	0.4337	II
Home to minibus pole	0.4000	I	Minibus pole to destination	0.3600	II	Minibus	0.3600	I	Minibus	0.4345	I
Home to highway toll gate	0.2100	II	Highway toll gate to destination	0.2500	III	Car	0.3000	III	Car	0.1317	III
Differences											
Jakarta Intracity Link			Bandung Intracity Link			Intercity Transport			Intercity Modal Competition		
Link 1	δ	%	Link 2	δ	%	Modes	δ	%	Modes	δ	%
Home to rail station	0.0100	1	Rail station to destination	0.0800	8	Train	0.0800	8	Train	0.0096	0.96
Home to minibus pole	0.0000	0	Minibus pole to destination	0.1400	14	Minibus	0.0600	6	Minibus	0.0548	5.48
Home to highway toll gate	0.0100	1	Highway toll gate to destination	0.0600	6	Car	0.0200	2	Car	0.0471	4.71

Table 4.22 Calculation of Final Modal Choice by Second Equation of the AMML Model

Obtained Probability Values by Combination Constants and Utility Value										
Jakarta Intracity Link			Bandung Intracity Link			Intercity Transport			Intercity Modal Competition		
Link 1	Probability of Choice	Choice	Link 2	Probability of Choice	Choice	Modes	Probability of Choice	Choice	Modes	Conditional Probability of Choice	Final Choice
Home to rail station	0.2800	III	Rail station to destination	0.2200	II	Train	0.4200	I	Train	0.2547	II
Home to minibus pole	0.3200	I I	Minibus pole to destination	0.7300	I	Minibus	0.3000	II	Minibus	0.6900	I
Home to highway toll gate	0.4000	I	Highway toll gate to destination	0.0500	III	Car	0.2800	III	Car	0.0551	III
Model Validation Statistic (External Data)											
Jakarta Intracity Link			Bandung Intracity Link			Intercity Transport			Intercity Modal Competition		
Link 1	Probability of Choice	Choice	Link 2	Probability of Choice	Choice	Modes	Probability of Choice	Choice	Modes	Conditional Probability of Choice	Final Choice
Home to rail station	0.1400	III	Rail station to destination	0.3100	II	Train	0.3400	II	Train	0.1370	II
Home to minibus pole	0.3700	II	Minibus pole to destination	0.6200	I	Minibus	0.3600	I	Minibus	0.7672	I
Home to highway toll gate	0.4900	I	Highway toll gate to destination	0.0700	III	Car	0.3000	III	Car	0.0956	III
Differences											
Jakarta Intracity Link			Bandung Intracity Link			Intercity Transport			Intercity Modal Competition		
Link 1	δ	%	Link 2	δ	%	Modes	δ	%	Modes	δ	%
Home to rail station	0.1400	14	Rail station to destination	0.0900	9	Train	0.0800	8	Train	0.11761	1.17
Home to minibus pole	0.0500	5	Minibus pole to destination	0.1100	11	Minibus	0.0600	6	Minibus	0.0772	7.72
Home to highway toll gate	0.0900	9	Highway toll gate to destination	0.0200	2	Car	0.0200	2	Car	0.04046	4.04

Table 4.23 Modal Choice in Intracity Transport at Bandung

Intracity Bandung	Values	Choice I
Go to Rail station	0.6300	I
Go to Minibus Pole	0.2300	II
Go to Highway toll gate	0.1400	III

After they arrived at arrival city Jakarta, then they consider intracity transport in the city. By using eq. 3.20, for railway, intracity transport at Jakarta is not the constraint. It has the first position after minibus. The third is car. Minibus pole has several locations at Jakarta but they are enough to give the good access to their passengers when arrive there. The same situation at Bandung, car has similar problem in Jakarta. Highway toll gate is not located at the center of the city.

Table 4.24 Modal Choice in Intracity Transport at Jakarta

Intracity Jakarta	Values	Choice II
From Rail station	0,6700	I
From Minibus Pole	0,2300	II
From Highway toll gate	0,1000	III

By using eq. 3.22, as a mode of intracity transport, in Bandung passengers' opinion train is not good enough in comparing with other modes. It only reaches the third level than other modes. The second is minibus, and the first is car. It means, there are several quality variables of railway that has to improve in modal competition. Even though railway is supported by its intracity transport condition, but if it cannot give the good service by itself, it is not enough in total passenger transport chain.

Table 4.25 Modal Choice in Intercity Link

Intercity Link	Values	Choice III
Train	0.0010	II
Minibus	0.0100	II
Car	0.9890	I

We use "AMML" Model to prove which one is the best in modal competition on this link (eq., 3.31). The intracity transport condition cannot penalize car as the first choice. That means too, a possible opportunity to increase the attractiveness of train by improving its services.

Table 4.26 Modal Choice in Total Passengers Transport Chain

Intercity Modal competition	Values	Choice Final
Train	0.0272	III
Minibus	0.0340	II
Car	0.9388	I

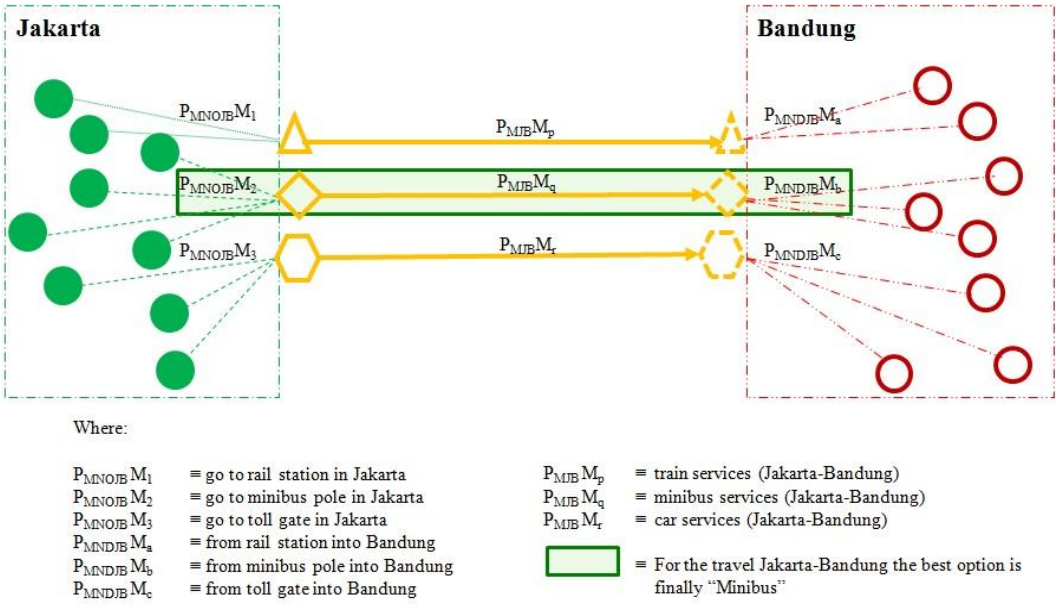


Figure 4.23 Choices from Bandung to Jakarta will be inclined to Car

B2. Validation Results

With the same method of the direction Jakarta-Bandung (split half, after verification there are 149 questionnaires), the results of the direction Bandung-Jakarta were validated. The external data validation results showed that car is confirmed as the most competitive mode over the others (Table 4.27). The differences are in between 0-61.

The biggest difference is in the intracity transport mode choice at Bandung for minibus and train. Then, the validation continues to double check with the other equation of the AMML Model. The equation of the other AMML Model formulation refers to the eq. 3.48. The validation of the second calculation is confirmed again that car has the highest opportunity (Table 4.28).

4.7 Transportation Characteristics

Even though in the same corridor, but the favorable choice is different between passengers who travel from Jakarta to Bandung and as return, from Bandung to Jakarta. In these two directions, the results do not consider the first and the last mile distance. The results describe the passengers' journey with the nearest mode to use from their home and at their final destination.

Table 4.27 External Validation of Final Modal Choice in Intercity Transport at Bandung-Jakarta

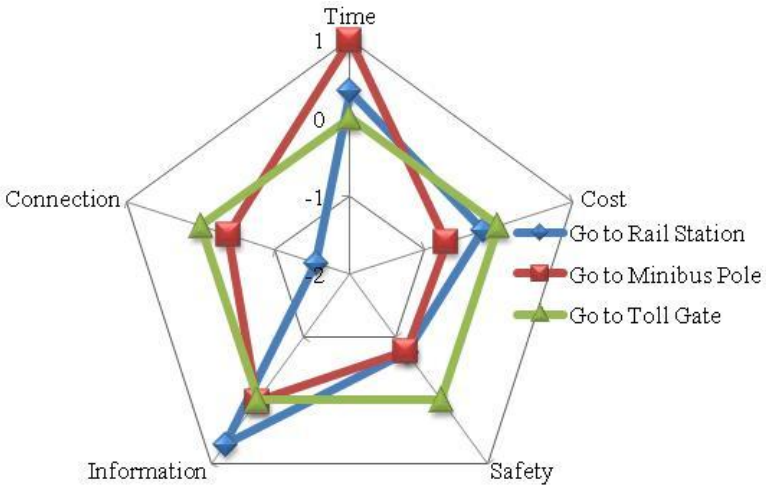
Model Validation Statistic (External Data)											
Bandung Intracity Link			Jakarta Intracity Link			Intercity Transport			Intercity Modal Competition		
Link 1	Probability of Choice	Choice	Link 2	Probability of Choice	Choice	Modes	Probability of Choice	Choice	Modes	Conditional Probability of Choice	Final Choice
Home to rail station	0.1300	II	Rail station to destination	0.8300	I	Train	0.0002	III	Train	0.0001	III
Home to minibus pole	0.8400	I	Minibus pole to destination	0.1100	II	Minibus	0.0020	II	Minibus	0.0555	II
Home to highway toll gate	0.0300	III	Highway toll gate to destination	0.0600	III	Car	0.9978	I	Car	0.9444	I
Differences											
Bandung Intracity Link			Jakarta Intracity Link			Intercity Transport			Intercity Modal Competition		
Link 1	δ	%	Link 2	δ	%	Modes	δ	%	Modes	δ	%
Home to rail station	0.5000	50	Rail station to destination	0.1600	16	Train	0.0008	0.08	Train	0.0271	2.71
Home to minibus pole	0.6100	61	Minibus pole to destination	0.1200	12	Minibus	0.0080	0.80	Minibus	0.0215	2.15
Home to highway toll gate	0.1100	11	Highway toll gate to destination	0.0400	4	Car	0.0088	0.88	Car	0.0056	0.56

Table 4.28 Calculation of Final Mode Choice in Intercity Transport Mode at Bandung-Jakarta Direction by Second Equation of the AMML Model

Obtained Probability Values by Combination Constants and Utility Value										
Bandung Intracity Link			Jakarta Intracity Link			Intercity Transport			Intercity Modal Competition		
Link 1	Probability of Choice	Choice	Link 2	Probability of Choice	Choice	Modes	Probability of Choice	Choice	Modes	Conditional Probability of Choice	Final Choice
Home to rail station	0.0600	III	Rail station to destination	0.0900	III	Train	0.0005	III	Train	0.0000	III
Home to minibus pole	0.3700	II	Minibus pole to destination	0.3900	II	Minibus	0.0020	II	Minibus	0.0010	II
Home to highway toll gate	0.5700	I	Highway toll gate to destination	0.5200	I	Car	0.9975	I	Car	0.9990	I
Model Validation Statistic (External Data)										
Bandung Intracity Link			Jakarta Intracity Link			Intercity Transport			Intercity Modal Competition		
Link 1	Probability of Choice	Choice	Link 2	Probability of Choice	Choice	Modes	Probability of Choice	Choice	Modes	Conditional Probability of Choice	Final Choice
Home to rail station	0.0800	III	Rail station to destination	0.0900	III	Train	0.0002	III	Train	0.0000	III
Home to minibus pole	0.2900	II	Minibus pole to destination	0.3900	II	Minibus	0.0020	II	Minibus	0.0007	II
Home to highway toll gate	0.6300	I	Highway toll gate to destination	0.5200	I	Car	0.9978	I	Car	0.9993	I
Differences										
Bandung Intracity Link			Jakarta Intracity Link			Intercity Transport			Intercity Modal Competition		
Link 1	δ	%	Link 2	δ	%	Modes	δ	%	Modes	δ	%
Home to rail station	0.0200	2	Rail station to destination	0	0	Train	0,0003	0.03	Train	0.0000	0
Home to minibus pole	0.0800	8	Minibus pole to destination	0	0	Minibus	0	0	Minibus	0.0003	0.03
Home to highway toll gate	0.0600	6	Highway toll gate to destination	0	0	Car	0,0003	0.03	Car	0.0003	0.03

4.7.1 Quality Services Transportation on the Direction Jakarta-Bandung

At Jakarta (Fig.4.24), the strengths of intracity transport from home to rail station are connection (- 1.548), safety (- 0.759), and cost (- 0.205). The competitiveness of railway could be increased by supplying information of Jakarta intracity transport condition to passengers (0.704) and decreasing travel time to go to rail station (0.337). For minibus service, it was supported by safety condition (- 0.769) of intracity transport at Jakarta to go to its pole, affordable cost (- 0.697), and good connection condition (- 0.367). The competitiveness of minibus could be increased by reducing travel time (0.994) and supplying information of intracity transport at Jakarta (0.017).



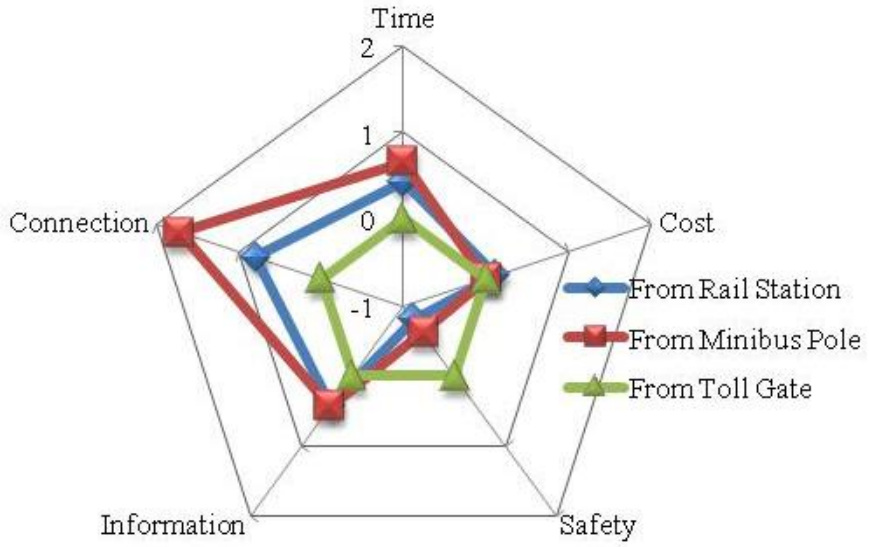
Note: Strengths to go to rail station in intracity transport modal competition at Jakarta are connection, safety, and cost.

Figure 4.24 Utility Function Coefficients for Intracity Transport at Jakarta as Departure City

Furthermore, it means that passengers who live in Jakarta said that some variables of intracity transport to go to rail station and minibus pole are good enough in

connection, safety condition and cost, but the available intracity transport information to get there has to supply and the travel time has to reduce. Congestion in Jakarta City is really in bad condition.

The strengths of intracity transport at Bandung (Fig.4.25), when passengers have arrived at rail station, are safety condition (- 0.807). The competitiveness of railway could be increased by giving good connection at rail station (0.795), reducing travel time of Bandung intracity transport (0.425), supplying information of intracity transport alternatives (0.425), and decreasing transport cost (0.115). For minibus service, it was also supported by safety condition (- 0.620) of competitiveness of minibus could be continued by giving good connection at the pole (1.715), reducing travel time of Bandung intracity transport (0.654), supplying information of intracity transport alternatives (0.442), and decreasing transport cost (0.003).

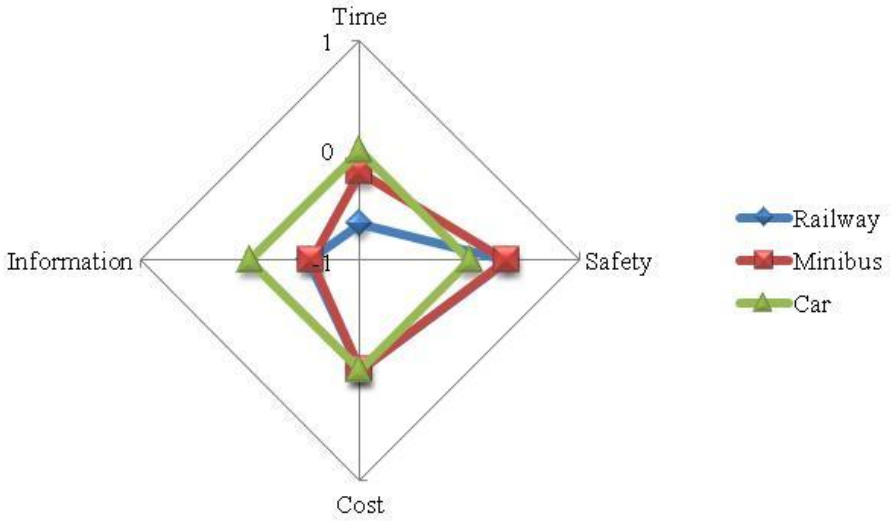


Note: Strengths to go to their destination from rail station to destination at Bandung is only safety.

Figure 4.25 Utility Function Coefficients for Intracity Transport at Bandung as Arrival City

Passengers who live in Jakarta consider that intracity transport at Bandung feels safe enough. Bandung is known by its hospitality as tourism area and lower size than Jakarta. But local transport in Bandung is not really good in managing the connection. It takes a long duration to get the final destination. It is not only because of the congestion but also the available mode choices of transport as alternatives to arrive at final destination are lower than in Jakarta. Moreover, passenger cannot reach easily the information of the available modes at intracity transport at Bandung, because of that they have to spend more money and take taxi which is always stand by in the rail station or minibus pole.

The strengths of train (Fig.4.26) are travel time (- 0.672) and available information (- 0.539). The competitiveness of train could be increased by giving good safety condition (0.342), while cost is already achieved at the same competitive level. For minibus service, its strength was the good information services (- 0.556) and good enough in travel time (- 0.193). The competitiveness of minibus could be continued by giving good safety condition (0.337).



Note: Strengths of train for the transport service Jakarta-Bandung are travel time, and available information

Figure 4.26 Utility Function for Intercity Transport on the Direction Jakarta-Bandung

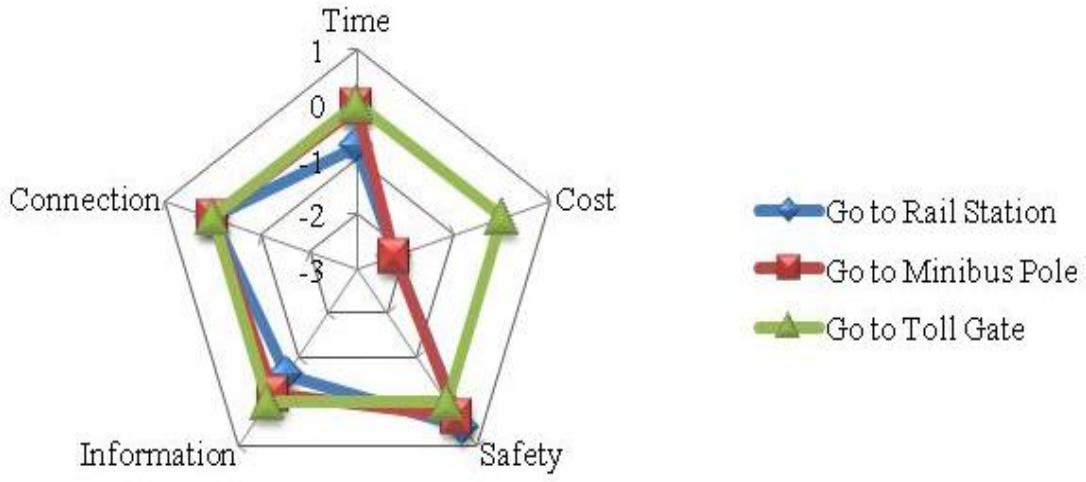
Apart the calculation of intracity transport condition, passengers considers that train can give the lowest travel time in intercity transport and the information at the rail station is good. As public transport, they consider that the safety condition is not good enough.

Table 4.29 Quality Services Variables Comparison on the Direction Jakarta-Bandung

Intracity Transport at Origin, **JAKARTA**			
Service Variables	**Go to Rail Station**	**Go to Minibus Pole**	**Go to Toll Gate**
Travel Time	**0.337**	**0.994**	0
Quality Price/Cost	-0.205	-0.697	**0**
Safety	-0.759	-0.769	**0**
Information	**0.704**	**0.017**	0
Connection	-1.548	-0.367	**0**
Intracity Transport at Destination, **BANDUNG**			
Service Variables	**From Rail Station**	**From Minibus Pole**	**From Toll Gate**
Travel Time	**0.425**	**0.654**	0
Quality Price/Cost	**0.115**	**0.003**	0
Safety	-0.807	-0.620	**0**
Information	**0.425**	**0.442**	0
Connection	**0.795**	**1.715**	0
Intercity Mode Choice on the Link **JAKARTA-BANDUNG**			
Service Variables	**Train**	**Minibus**	**Car**
Travel Time	-0.672	-0.193	**0**
Quality Price/Cost	0	0	0
Safety	**0.342**	**0.337**	0
Information	-0.539	-0.556	**0**

4.7.2 Quality Services Transportation on the Direction Bandung-Jakarta

At Bandung, the strengths of intracity transport from home to go to rail station are cost (-.227), travel time (- 0.765), and information (- 0.624). The competitiveness of railway could be increased by giving safety condition of Bandung intracity transport condition to passengers (0.547). For minibus service, it was supported by affordable cost (- 2.238) of intracity transport at Bandung to go to its pole, enough information (- 0.192), and good travel duration (-0.060). The competitiveness of minibus could be increased by giving safety condition (0.338) of intracity transport at Bandung.



Note: Strengths to go to rail station in at Bandung are cost, travel time and information

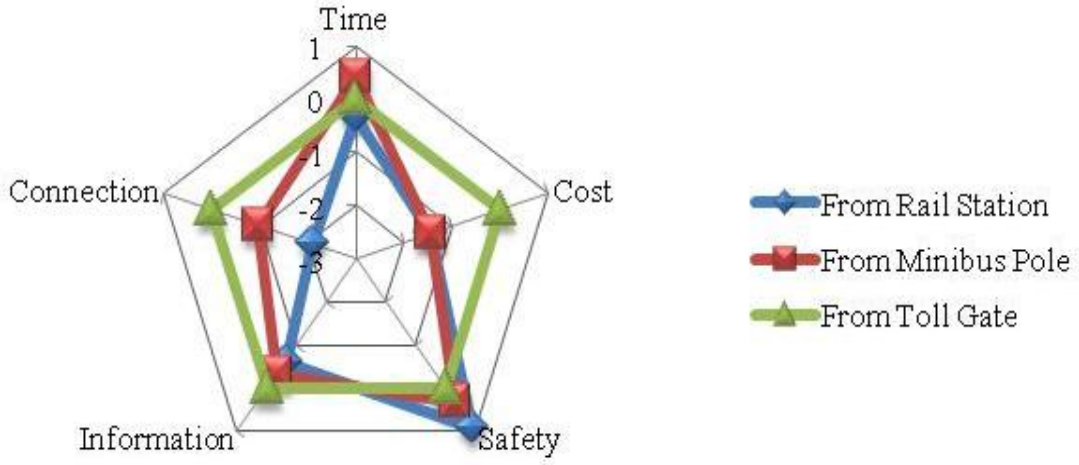
Figure 4.27 Utility Function Coefficients for Intracity Transport at Bandung as Departure City

Passengers who live in Bandung feel that intracity transports at Bandung are still not safe enough, although passengers who live in Jakarta said that it is safe enough. But for them local transport in Bandung is good in connection, cost, information and

travel time. They live there and already know intracity transport in Bandung better than passengers who live in Jakarta.

The strengths of intracity transport at Jakarta, when passengers have arrived at rail station, are connection (- 2.086), cost (- 1.446), information (- 0.618), and travel time (- 0.331). The competitiveness of railway could be increased by supporting safety condition (0.900). For minibus service, it has advantages of cost level (- 1.441), connection (- 0.957), and information (- 0.339) at intracity Jakarta from its pole to passengers destination. The competitiveness of minibus could be continued by reducing travel time (0.405) and improving safety condition (0.316).

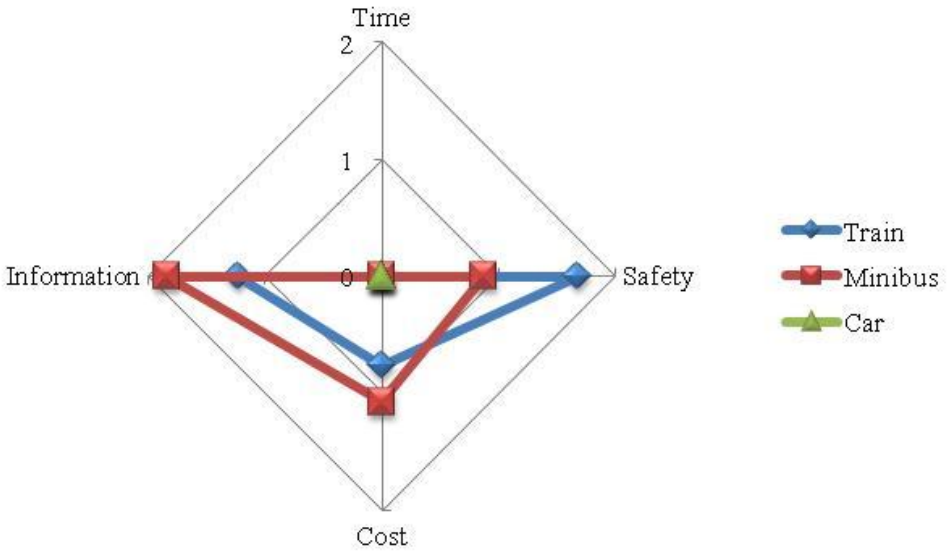
Railway passengers still not feel safe with intracity transport at Jakarta and the rest variables are still good enough. But for minibus passengers, beside to improve safety condition, the most important is reducing the travel time.



Note: Strengths to go from rail station at Jakarta to destination are all factors except the safety

Figure 4.28 Utility Function Coefficients for Intracity Transport at Jakarta as Arrival City

The travel time reach the same level among train, minibus, and car at intercity link. The competitiveness of train could be increased by giving good safety condition (1.669), available information (1.238) and give more competitive services with the actual cost (0.762). For minibus service, its services are below the others mode.



Note: The train has only weakness for the transport service Bandung-Jakarta in comparison with car

Figure 4.29 Utility Function Coefficients for Intercity Transport on the direction Bandung-Jakarta

Table 4.30 Quality Services Variables Comparison the direction Bandung-Jakarta

Intracity Transport at Origin **BANDUNG**			
Service Variables	**Go to Rail Station**	**Go to Minibus Pole**	**Go to Toll Gate**
Travel Time	-0.765	-0.06	**0**
Quality Price/Cost	-2.227	-2.238	**0**
Safety	**0.547**	**0.338**	0
Information	-0.624	-0.192	**0**
Connection	0	0	0
Intracity Transport at Destination **JAKARTA**			
Service Variables	**From Rail Station**	**From Minibus Pole**	**From Toll Gate**
Travel Time	-0.331	**0.405**	0
Quality Price/Cost	-1.446	-1.441	**0**
Safety	**0.9**	**0.316**	0
Information	-0.618	-0.339	**0**
Connection	-2.086	-0.957	**0**
Intercity Mode Choice on the Link **BANDUNG-JAKARTA**			
Service Variables	**Train**	**Minibus**	**Car**
Travel Time	0	0	0
Quality Price/Cost	**0.762**	**1.077**	0
Safety	**1.669**	**0.871**	0
Information	**1.238**	**1.841**	0

CHAPTER V CONCLUSION AND PERSPECTIVES

5.1 Conclusion

Adapted Mixed Multinomial Logit (AMML) model" is a model that has been developed from the Multinomial Logit Model for the analysis of alternative modes of transportation between the two cities to include the characteristics of the transport in the city. The case study on the transport network has been established at the Jakarta-Bandung corridor, and has resulted in a formulation that can be used to evaluate the performance of modes of transport that connects the two cities. The characteristics of the transport network between the two cities have been expressed in the coefficient β. This coefficient obtained from the process of identifying the parameters of the model AMML.

5.1.1 The Consideration of Intracity Transport System in Intercity Mode Choices

Characteristics of transport in the city have a strong relationship in determining the choice of the type of inter-city transportation mode. Efforts to improve the performance of one type of mode in an inter-city network will not be optimal when it is not supported by the increase in performance of modes of transport in the two cities. Transportation modes can be chosen by the passenger, each mode of transport should have the characteristics of the service as required by the passenger. The design of the service level of each type of mode of transportation between cities can include characteristics of the overall service network, the transport network in the city and inter-city network.

5.1.2 Model Development

The AMML model has two equations, the first is using multi utility functions and the second is using combination between constants and utility function. The second equation could confirm the first results equation. The confirmation results also could do by using external data that can apply to the two equations. There are some limitations to consider. The model could apply with its requirements.

5.1.3 Improving Mode's Competitiveness

The survey was done in systematically process, and the final step the models have been verified by the statistical tests and have been confirmed by external validation. The results describe the passengers' journey with the nearest mode to use from their home and at their final destination.

From the analysis of the results are as follows:

1. The quality service variables are in the respective order :
   a. travel time, cost, safety, information, and connection for intracity at departure and destination cities
   b. travel time, cost, safety and information for intercity mode services
2. From this study it can be seen that the preference of passengers to travel Jakarta - Bandung is minibus transport modes, but to Bandung - Jakarta is the private car.

5.1.4 Model Simulation

The model generic was present in the model development and it was applied on the direction Jakarta-Bandung and Bandung-Jakarta. The applications have produced two

certain models which can be simulated to the future conditions. The simulation model was needed to predict the competitiveness of the one mode over the other modes.

5.2 Perspectives

Based on the analysis and discussion, some suggestions are proposed:

1. Recommendation for policies and regulations:
    a. Characteristics of each mode of transportation are very different to fulfill passengers' demands, so some policies towards all modes are needed.
    b. Travel time, cost, safety, information availability, and connection condition need to be improve in particular for the railway transport. Any policy to regulate those services should promote equality for all modes to be chosen by passengers.
    c. The results of our research allow different proposals for the improvement of transportation policies in the context of sustainable urban and regional development.

2. Perspective for further research:

    This research can also be adapted to other types of modes, such as high speed rail that the government plans to develop for Jakarta-Bandung and the Jakarta-Surabaya corridor. Beside of the replication, this research can also still be explored with the same data to determine the final choice of specified segment market of intercity transport, such as the final decision for workers, students, or tourists.

    The methodology of this study can also be used for the analysis of the minibus and car transportation segments. It can be also useful for the freight transportation (global or segmented) between big cities.

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Annex

Data Compilation and Analysis

1. Data Compilation

a. Choices Data

When data entry has been finished, then data compilation started to define variables values. Choice values are identified by the answer of the question with notation "V.1 ≡ Kendaraan yang paling sering digunakan antar kota Jakarta-Bandung".

- If they answered train then the notation in xl file would become
  - $Mo_1 = 1$, is the value to go to rail station
  - $Mi_1 = 1$, is the value of train
  - $M_{D1} = 1$, is the value from rail station
- if minibus, then:
  - $Mo_2 = 2$, is the value to go to minibus pole
  - $Mi_2 = 2$, is the value of minibus
  - $M_{D2} = 2$, is the value from minibus pole
- and if car then:
  - $Mo_3 = 3$, is the value to go to highway toll gate
  - $Mi_3 = 3$, is the value of car
  - $M_{D3} = 3$, is the value from highway toll gate

b. Intracity Transport at Departure City

There are five service variables to consider on this link.

- Travel time to go to modal node (TtoU) is the additional of travel time when passengers used one or several modes to go to modal node 1 (for example rail station, minibus pole, or highway toll gate). The values that

has been used:

- ”III.2Wr ≡ Kondisi kendaraan Ojek/Motor, Waktu Rata-rata”
- ”III.3Br ≡ Kondisi kendaraan Bajaj/Becak, Biaya Rata-rata”
- ”III.4Wr ≡ Kondisi kendaraan Angkot/Metromini, Waktu Rata-rata”
- ”III.5Wr ≡ Kondisi kendaraan Taxi, Waktu Rata-rata”
- ”III.6Wr ≡ Kondisi kendaraan Mobil Pribadi, Waktu Rata-rata”
- ”III.7Wr ≡ Kondisi kendaraan Bis, Waktu Rata-rata”

- Cost (PoU) has been spent to go to modal node. The values that has been used are the additional values from:
  - ”III.2Br ≡ Kondisi kendaraan Ojek/Motor, Biaya Rata-rata”
  - ”III.3Br ≡ Kondisi kendaraan Bajaj/Becak, Biaya Rata-rata”
  - ”III.4Br ≡ Kondisi kendaraan Angkot/Metromini, Biaya Rata-rata”
  - ”III.5Br ≡ Kondisi kendaraan Taxi, Biaya Rata-rata”
  - ”III.6Br ≡ Kondisi kendaraan Mobil Pribadi, Biaya Rata-rata”
  - ”III.7Br ≡ Kondisi kendaraan Bis, Biaya Rata-rata”
- Safety condition to go to modal node (SoC), the values that has been used are the additional values from:
  - ”III.2K ≡ Kondisi kendaraan Ojek/Motor, Keamanan”
  - ”III.3K ≡ Kondisi kendaraan Bajaj/Becak, Keamanan”
  - ”III.4K ≡ Kondisi kendaraan Angkot/Metromini, Keamanan”
  - ”III.5K ≡ Kondisi kendaraan Taxi, Keamanan”
  - ”III.6K ≡ Kondisi kendaraan Mobil Pribadi, Keamanan”
  - ”III.7K ≡ Kondisi kendaraan Bis, Keamanan”
- Information condition to go to modal node (IoC), the values that has been used are the additional values from:
  - ”III.2I ≡ Kondisi kendaraan Ojek/Motor, Informasi”
  - ”III.3I ≡ Kondisi kendaraan Bajaj/Becak, Informasi”
  - ”III.4I ≡ Kondisi kendaraan Angkot/Metromini, Informasi”
  - ”III.5I ≡ Kondisi kendaraan Taxi, Informasi”

- ”III.6I ≡ Kondisi kendaraan Mobil Pribadi, Informasi”
- ”III.7I ≡ Kondisi kendaraan Bis, Informasi”

- Connection condition at modal node 1 (CoC). The nominal values were classified with Sturges rank, then it can be got the total values from:
  - ”IV.1W ≡ Waktu tunggu rata-rata ketika akan keluar kota dari kota asal”
  - ”IV.4B ≡ Biaya tunggu rata-rata ketika akan keluar kota”
  - ”IV.5 ≡ Keamanan ditempat tunggu ketika akan keluar kota”
  - ”IV.6 ≡ Ketersediaan informasi ditempat tunggu ketika akan keluar kota”

c. Intercity transport

There are four variables for this link. The values that have been obtained from:

- Travel time (TtiU) is from notation “V.2Wr ≡ Kondisi kendaraan antar kota, Waktu Rata-rata”
- Cost (PiU) is from notation “V.2Br ≡ Kondisi kendaraan antar kota, Biaya Rata-rata”
- Safety condition (SiC) is from notation “V.2K ≡ Kondisi kendaraan antar kota, Keamanan”
- Information condition (IiC) is from notation “V.2I≡Kondisi kendaraan antar kota, Informasi”

d. Intracity Transport at Departure City

- Travel time from modal node (TtdU) is the additional of travel time when passengers used one or several modes from modal node 2 (for example rail station, minibus pole, or highway toll gate) to go to the final destination. The values that has been used:
  - ”VI.2Wr ≡ Kondisi kendaraan Ojek/Motor, Waktu Rata-rata”

- ”VI.3Wr ≡ Kondisi kendaraan Bajaj/Becak, Waktu Rata-rata”
- ”VI.4Wr ≡ Kondisi kendaraan Angkot/Metromini, Waktu Rata-rata”
- ”VI.5Wr ≡ Kondisi kendaraan Taxi, Waktu Rata-rata”
- ”VI.6Wr ≡ Kondisi kendaraan Mobil Pribadi, Waktu Rata-rata”
- ”VI.7Wr ≡ Kondisi kendaraan Bis, Waktu Rata-rata”

- Cost (PdU) has been spent from modal node 2 to go to final destination. The values that has been used are the additional values from:
  - ”VI.2Br ≡ Kondisi kendaraan Ojek/Motor, Biaya Rata-rata”
  - ”VI.3Br ≡ Kondisi kendaraan Bajaj/Becak, Biaya Rata-rata”
  - ”VI.4Br ≡ Kondisi kendaraan Angkot/Metromini, Biaya Rata-rata”
  - ”VI.5Br ≡ Kondisi kendaraan Taxi, Biaya Rata-rata”
  - ”VI.6Br ≡ Kondisi kendaraan Mobil Pribadi, Biaya Rata-rata”
  - ”VI.7Br ≡ Kondisi kendaraan Bis, Biaya Rata-rata”
- Safety condition from modal node 2 (SdC), the values that has been used are the additional values from:
  - ”VI.2K ≡ Kondisi kendaraan Ojek/Motor, Keamanan”
  - ”VI.3K ≡ Kondisi kendaraan Bajaj/Becak, Keamanan”
  - ”VI.4K ≡ Kondisi kendaraan Angkot/Metromini, Keamanan”
  - ”VI.5K ≡ Kondisi kendaraan Taxi, Keamanan”
  - ”VI.6K ≡ Kondisi kendaraan Mobil Pribadi, Keamanan”
  - ”VI.7K ≡ Kondisi kendaraan Bis, Keamanan”
- Information condition (IdC) from modal node 2, the values that has been used are the additional values from:
  - ”VI.2I ≡ Kondisi kendaraan Ojek/Motor, Informasi”
  - ”VI.3I ≡ Kondisi kendaraan Bajaj/Becak, Informasi”
  - ”VI.4I ≡ Kondisi kendaraan Angkot/Metromini, Informasi”
  - ”VI.5I ≡ Kondisi kendaraan Taxi, Informasi”
  - ”VI.6I ≡ Kondisi kendaraan Mobil Pribadi, Informasi”
  - ”VI.7I ≡ Kondisi kendaraan Bis, Informasi”

- Connection condition at modal node 2 (CdC). The nominal values were classified with Sturges rank, then it can be got the total values from:
  - ”VII.1W ≡ Waktu tunggu rata-rata ketika tiba ditempat tujuan”
  - ”VII.3B ≡ Biaya rata-rata ketika tiba ditempat tujuan”
  - ”VII.5 ≡ Keamanan ditempat tunggu ketika tiba ditempat tujuan”
  - ”VII.6 ≡ Ketersediaan informasi ditempat tunggu ketika tiba ditempat tujuan”

2. Data Verification

Data verification was done by checking data input in excel files with questionnaires requirements as mention in the guideline. Data could missed placed or text format. Data with the illogic input was deleted. Data verification was done twice to avoid human error.

3. Data Classification

Numeric data is classified by Sturges equation, so all data format is data rank.

$k = 1 + 3{,}322 \log n$ …….. (1)

Where:

n ≡ total number of data available

k ≡ number of classification

$i \equiv r/k$ …….. (2)

i ≡ interval

r ≡ value max – value min……(3)

Data was divided into type, such as data for model development and data for external validation. There are two table for model development, such as data Jakarta-Bandung (Table 1, 2, and 3) and data Bandung-Jakarta (Table 4, 5, and 6).

Tabel 1 Classified Data of Train Package on the Jakarta-Bandung Direction

Respondent	TtoU	PoU	SoC	IoC	CoC	TtiU	PiU	SiC	IiC	TtdU	PdU	SdC	IdC	CdC
1	8	7	6	6	5,5	4	8	4	4	7	5	6	6	6,5
2	7	7	6	6	5	4	8	6	6	7	7	6	6	7
3	8	8	6	6	6,5	4	8	6	6	8	8	6	6	6
4	7	7	6	6	6	4	8	6	6	6	8	6	6	6,5
5	8	8	6	6	6,5	4	8	6	6	6	8	6	6	6,5
6	8	8	6	6	6,5	2	8	6	6	5	8	4	6	5
7	8	8	6	6	7	5	8	6	6	7	5	8	8	5,5
8	7	5	8	8	6	5	8	8	8	8	5	6	6	6
9	7	8	6	6	5,5	4	8	8	8	7	8	4	6	4
10	7	8	6	6	6,5	4	8	8	8	4	5	8	8	6
11	8	7	6	6	6,5	4	8	6	6	7	7	6	6	6
12	6	8	4	6	7	4	8	6	6	6	8	6	6	6,5
13	6	8	6	6	6	4	8	6	6	6	8	6	6	7
14	7	8	6	6	7	4	8	6	6	6	8	6	6	7
15	7	8	6	6	7	4	8	6	6	8	8	4	6	6,5
16	6	8	6	6	7	2	8	6	6	7	8	4	6	6,5
17	8	8	6	6	5	4	8	6	6	7	8	6	6	5,5
18	7	7	6	6	6	4	8	6	6	7	6	6	6	6,5
19	8	7	6	6	5	4	8	6	6	6	8	6	6	6,5
20	7	7	6	6	6	2	8	6	6	8	8	4	6	7
21	7	8	6	6	5	4	8	6	6	5	8	6	6	6
22	7	8	6	6	5	4	8	6	6	6	8	6	6	6
23	8	8	6	6	6,5	4	8	6	6	8	8	6	6	7
24	8	7	6	6	6	4	8	6	6	7	6	6	6	7
25	8	7	6	6	4	5	8	6	6	8	7	6	6	6,5
26	8	7	6	6	6	2	8	6	8	7	7	4	6	6,5
27	7	8	4	4	6	4	8	6	6	7	7	6	6	6,5
28	7	6	6	6	6	5	8	8	6	7	7	6	6	6,5
29	8	8	6	6	6	2	8	6	6	8	8	6	6	6
30	7	6	6	8	5,5	4	8	6	6	8	8	4	6	6
31	7	5	6	6	4,5	2	8	6	6	8	8	6	6	7
32	8	7	5	5	6,5	2	7	6	6	8	8	4	4	7
33	7	7	6	6	6	2	8	6	6	6	4	6	6	5
34	8	7	6	6	5,5	2	8	6	6	7	8	6	6	6
35	8	8	6	6	6,5	2	8	6	6	8	8	6	6	6,5
36	7	5	6	6	6,5	2	8	4	4	6	5	6	6	6
37	8	8	6	6	6,5	4	8	6	6	6	8	4	6	6
38	8	8	6	6	6	4	8	6	6	5	8	6	6	5
39	7	6	4	6	6,5	2	8	6	6	8	8	6	6	7
40	8	8	4	6	6,5	4	8	6	6	8	8	6	6	7
41	8	7	8	8	8	4	8	6	6	7	5	6	6	6,5
42	8	8	8	8	6	4	8	6	6	8	7	6	6	7
43	8	8	6	6	6	2	8	6	6	4	8	6	6	6
44	7	8	6	6	6,5	4	8	6	6	4	8	6	6	7
45	7	8	4	6	7	4	8	6	6	7	8	6	6	6,5
46	8	8	6	6	7	2	8	6	6	8	8	4	6	7
47	8	7	6	6	6	2	8	6	6	8	7	6	6	7
48	7	8	6	6	6,5	4	8	6	6	8	8	6	6	7
49	7	5	6	6	5,5	5	8	6	6	5	1	6	6	7
50	6	8	6	5	7	4	8	6	6	8	8	4	6	7
51	7	8	6	4	6,5	5	8	6	6	6	8	4	6	7
52	8	7	6	6	6	4	8	6	6	8	8	6	6	6,5
53	8	8	6	6	5,5	5	8	6	6	8	7	6	6	6,5
54	8	7	6	6	5,5	4	8	6	6	7	7	6	6	6
55	8	6	6	6	6,5	4	8	6	6	8	6	6	6	6,5
56	8	7	4	6	6,5	2	8	6	6	8	8	6	6	7
57	8	7	6	6	6	4	8	6	6	7	8	6	6	6
58	6	8	4	6	5,5	4	8	6	6	6	8	6	6	6
59	7	8	4	6	5,5	2	8	6	4	8	5	6	6	5,5
60	7	7	6	6	6,5	4	8	8	8	8	5	6	6	6
61	8	7	6	6	6	4	8	6	6	8	6	6	6	5,5
62	3	8	6	6	6,5	2	8	6	6	7	5	6	6	6,5
63	7	8	6	6	4,5	2	8	6	6	7	8	6	6	6
64	1	8	4	6	5,5	4	8	6	6	7	8	6	6	7
65	8	8	4	6	6,5	4	8	6	6	6	8	4	6	5,5
66	8	7	6	6	5,5	4	8	6	6	8	6	6	6	5
67	7	5	6	6	5	4	8	6	6	7	7	6	6	4,5
68	8	7	6	6	7	4	8	6	6	8	7	6	6	7
69	7	7	6	6	6	4	8	6	6	8	6	6	6	4,5
70	7	8	6	6	6	4	8	6	6	7	7	6	6	5,5
71	7	8	6	6	6,5	2	8	6	6	8	8	6	6	6,5
72	8	8	6	6	7	4	8	6	6	6	4	6	6	6,5
73	8	8	6	6	6,5	4	8	6	6	7	8	6	6	7
74	7	7	6	6	6	4	8	6	6	8	6	6	6	4,5
75	7	5	8	8	6,5	2	8	6	6	8	6	6	6	6,5
76	8	5	6	6	5	1	8	6	6	7	7	6	6	4,5
77	6	8	6	6	5	1	8	6	6	7	8	6	6	6
78	8	7	6	6	6	4	8	6	6	8	7	6	6	5,5
79	7	5	6	6	6,5	4	8	6	6	8	8	6	6	6
80	6	7	6	6	5,5	4	8	6	6	7	7	6	6	5,5
81	6	8	6	6	6,5	4	8	6	6	6	8	6	4	7
82	7	8	6	6	6,5	4	8	6	6	8	8	4	6	7
83	7	5	6	6	6	4	8	6	6	8	7	6	6	7
84	5	5	6	6	3,5	5	8	6	6	7	5	6	6	7
85	7	8	4	6	6,5	4	8	6	6	8	7	6	6	6,5
86	7	8	6	6	7	5	8	6	6	8	8	6	6	6,5
87	7	8	6	6	6,5	4	8	6	6	8	8	6	6	7
88	7	6	6	6	6	4	8	6	6	8	8	6	6	7
89	8	8	6	6	4,5	4	8	6	6	7	7	6	6	7
90	7	8	6	6	7	4	8	6	6	8	8	6	6	6,5
91	7	5	6	6	6	4	8	6	6	7	6	6	6	7
92	8	8	6	6	4	4	8	6	6	8	6	6	6	6,5

Tabel 2 Classified Data of Minibus Package on the Jakarta-Bandung Direction

Respondent	TtoU	PoU	SoC	IoC	CoC	TtiU	PiU	SiC	IiC	TtdU	PdU	SdC	IdC	CdC
1	8	8	6	4	6	4	8	6	6	8	8	6	6	7,5
2	8	7	4	6	6,5	4	8	6	6	8	8	6	6	6,5
3	7	8	4	6	6	5	8	6	6	8	8	6	6	7
4	7	7	2	2	7	4	8	6	6	8	8	6	6	7
5	8	7	6	6	6	4	8	6	6	8	8	6	6	6,5
6	8	7	6	6	6	5	8	6	4	8	7	6	6	6,5
7	7	8	6	6	6,5	5	8	6	6	8	6	6	6	5
8	8	7	6	6	6	5	8	6	6	8	8	4	6	7
9	8	8	4	6	6	4	8	6	6	8	8	4	6	6,5
10	7	8	8	6	6	4	8	6	6	7	6	6	6	6
11	8	7	4	4	6,5	4	8	6	6	8	8	8	6	5,5
12	8	7	6	6	6,5	5	8	6	6	8	8	4	6	7
13	8	8	4	4	6,5	7	8	6	6	8	8	4	6	6,5
14	7	6	6	4	6	4	8	6	6	7	8	8	8	7
15	8	7	4	4	5,5	4	8	6	6	8	8	4	6	5
16	8	8	4	4	6	4	8	6	6	7	5	4	6	5,5
17	7	6	6	4	6,5	4	8	6	6	7	8	8	8	7
18	7	8	4	4	6,5	4	8	6	6	7	6	6	6	6,5
19	7	8	4	4	6,5	4	8	6	6	7	7	6	6	6,5
20	8	7	6	6	8	5	8	8	8	8	8	8	8	8
21	8	7	6	6	8	5	8	6	6	8	8	8	8	8
22	8	7	8	8	7	5	8	6	6	1	6	8	6	6,5
23	8	5	4	4	5	7	7	6	6	8	5	6	6	5
24	8	7	6	6	6,5	4	8	8	8	8	8	6	6	6,5
25	8	8	6	4	5,5	7	8	6	4	8	8	6	4	6
26	7	8	6	4	6,5	5	8	6	6	7	5	6	6	6,5
27	7	8	4	6	7	5	8	6	8	8	8	8	8	8
28	6	5	6	6	6	4	8	6	6	7	6	6	6	6
29	8	7	4	8	6	4	8	6	6	8	8	4	6	6,5
30	8	8	4	6	5,5	7	8	6	6	8	6	6	6	6,5
31	8	8	4	6	6,5	7	8	6	6	8	6	6	6	6
32	8	8	4	6	6	4	8	6	6	8	7	6	6	7
33	8	7	6	6	5,5	4	8	6	6	8	8	8	8	6,5
34	8	6	6	6	7	4	8	6	6	8	8	6	6	6
35	8	8	6	6	7	4	8	6	6	8	8	6	6	6,5
36	8	6	6	6	6,5	4	8	6	6	7	8	8	8	7
37	8	7	4	4	7	4	8	6	6	7	6	8	8	6,5
38	8	8	6	6	7	4	8	6	6	8	8	6	6	7
39	8	8	4	4	7	4	8	6	6	7	8	6	6	7
40	8	8	6	6	7	4	8	6	6	7	7	8	8	7
41	8	8	6	6	6,5	4	8	6	6	7	8	6	6	7
42	7	8	6	6	7	4	8	6	6	4	6	6	6	7
43	8	8	4	4	7	4	8	6	6	8	8	4	6	7
44	8	8	4	4	7	4	8	6	6	8	8	4	4	7
45	7	5	6	6	6,5	4	8	6	6	8	8	6	6	7
46	8	8	6	6	7	4	8	6	6	8	8	6	6	6
47	8	8	6	6	7	5	8	6	6	8	8	6	6	6,5
48	8	6	6	6	6,5	4	8	6	6	8	8	6	6	6,5
49	8	8	6	6	6,5	4	8	6	6	8	8	6	6	7,5
50	7	5	6	6	5	4	8	6	6	8	8	6	8	7
51	7	5	6	6	7	1	8	6	6	8	6	6	6	7
52	8	7	6	6	5,5	4	8	6	6	8	5	6	6	7
53	7	5	6	6	5	4	8	6	6	8	8	6	6	7
54	7	8	6	6	7	2	8	6	6	8	7	6	6	6,5
55	8	8	6	6	5,5	4	8	6	6	8	8	8	8	7
56	7	5	6	6	6,5	4	8	6	6	8	6	6	6	7
57	8	6	6	6	6	3	8	6	6	8	8	4	4	5
58	8	7	6	6	6,5	4	8	6	6	8	7	6	6	6,5
59	7	6	6	6	5	5	8	4	4	7	6	6	6	6,5
60	8	7	8	8	7	4	5	6	6	8	7	6	6	7
61	7	6	8	6	7	7	8	6	6	6	6	6	6	7
62	8	8	6	6	7	4	8	6	6	8	8	4	4	7
63	6	7	2	2	6	4	8	8	6	5	5	2	2	6,5
64	6	5	8	8	7	5	8	8	8	5	5	8	8	7
65	7	8	6	6	7	4	8	6	6	8	8	4	6	6,5
66	7	8	6	6	5,5	4	8	6	6	7	8	6	6	7
67	6	8	12	12	6	4	8	6	6	8	8	6	6	7
68	7	8	6	6	6	1	8	6	6	6	8	6	6	6,5
69	8	7	6	4	6	4	8	4	4	3	5	6	6	6,5
70	7	8	4	4	7	8	8	6	6	5	6	6	4	7
71	7	5	6	6	6,5	7	8	6	6	7	5	6	6	7
72	7	8	6	6	6	4	8	6	6	6	8	6	6	7
73	8	7	8	8	7	4	8	6	6	8	7	4	6	6,5
74	8	7	8	8	7	4	8	6	6	8	8	8	8	7
75	8	8	6	6	5,5	2	8	6	6	8	8	8	8	7
76	8	8	6	6	7	4	8	8	8	8	8	8	8	7
77	8	8	6	6	5,5	4	8	6	6	8	8	8	8	7
78	8	8	6	6	5,5	4	8	6	6	7	8	6	6	6,5
79	8	8	4	4	6	4	8	6	6	8	8	4	6	7
80	8	5	6	6	7	7	8	6	6	8	8	6	6	6
81	7	7	6	6	6	4	8	6	6	7	8	4	4	6
82	7	5	6	6	7	4	8	6	6	8	8	6	6	7
83	8	8	4	4	7	4	8	6	6	8	8	4	4	7
84	7	6	6	6	6,5	4	8	6	6	7	8	6	6	7
85	8	7	4	6	6,5	4	8	6	6	8	6	6	6	6,5
86	8	7	4	6	7	4	8	6	6	8	6	6	6	6,5
87	8	7	4	6	7	4	8	6	6	8	6	6	6	6,5
88	6	6	6	6	6,5	7	8	6	6	7	8	6	6	6,5
89	6	6	6	8	7,5	4	8	8	8	7	8	4	6	7,5
90	5	5	6	6	6,5	7	8	6	6	4	8	6	6	6,5
91	6	5	4	4	6	4	8	8	8	7	5	4	6	5,5
92	8	7	4	6	7	4	8	6	6	8	6	6	6	6,5
93	8	7	4	6	7	4	8	6	6	8	6	6	6	6,5

Tabel 3 Classified Data of Car on the Jakarta-Bandung Direction

Respondent	TtoU	PoU	SoC	IoC	CoC	TtiU	PiU	SiC	IiC	TtdU	PdU	SdC	IdC	CdC
1	7	6	6	6	6,5	4	4	6	6	6	6	6	6	5,5
2	7	7	6	6	6,5	8	8	6	6	6	6	6	6	6
3	7	7	6	6	6,5	7	7	6	6	5	3	6	4	6
4	7	7	8	8	7,5	7	8	8	8	3	3	8	8	7
5	8	8	8	8	6,5	8	8	8	6	7	6	8	8	6
6	5	5	6	6	6,5	4	5	6	6	1	1	6	6	6
7	8	7	8	4	6,5	7	7	6	6	8	8	6	6	6
8	8	8	6	6	7,5	7	8	6	6	7	7	6	6	6,5
9	7	7	6	6	6,5	4	5	6	6	5	5	6	6	6
10	5	5	6	6	6,5	5	7	8	8	8	8	6	6	7
11	7	7	6	6	7	7	8	6	6	7	6	8	8	7
12	7	7	8	4	6	4	5	6	4	7	7	8	6	5,5
13	7	7	6	6	6,5	4	5	6	6	6	6	6	6	5,5
14	6	5	6	6	6,5	7	7	8	6	7	6	6	4	6,5
15	1	1	6	6	6,5	7	8	6	6	1	1	6	6	6
16	7	7	6	6	6,5	7	7	6	6	7	6	6	6	6
17	8	8	6	6	6,5	4	5	6	6	7	7	6	6	6
18	7	8	6	6	7	5	7	6	6	6	7	6	6	6
19	7	8	6	6	6,5	4	7	6	6	5	7	6	6	6
20	5	7	6	6	6,5	7	8	6	6	7	8	6	6	6
21	7	8	6	6	6,5	7	4	6	8	5	7	6	6	6
22	7	8	6	6	6,5	4	5	6	6	5	7	6	6	6
23	8	8	6	6	5,5	7	5	2	6	7	8	6	6	5
24	8	8	6	6	6,5	5	8	6	6	7	8	6	6	6
25	7	8	8	8	7,5	4	3	8	8	7	5	6	6	7
26	5	7	6	6	6,5	4	5	6	6	7	8	8	8	7
27	7	8	6	6	6,5	4	4	6	6	5	8	6	6	6,5
28	8	8	6	6	6,5	4	5	6	6	7	7	6	6	6
29	7	8	6	6	6,5	5	8	6	6	7	8	6	8	6
30	7	7	8	8	7	4	3	6	6	1	1	6	6	6,5
31	7	8	6	6	6,5	5	7	6	6	5	8	6	6	6
32	7	8	6	6	6,5	7	8	6	6	7	8	6	6	7
33	7	7	6	6	6,5	4	4	6	6	7	6	6	4	6
34	8	8	6	6	6,5	8	8	6	6	7	7	6	6	6
35	8	8	6	6	6,5	8	7	6	6	7	7	6	6	6
36	6	6	6	6	6,5	5	5	6	6	7	6	6	4	6
37	8	8	6	6	6,5	4	4	6	6	8	8	6	6	6
38	8	8	6	6	6,5	5	5	6	6	5	3	6	6	6
39	8	8	6	6	6,5	2	3	6	6	6	6	6	6	6
40	7	7	6	6	6,5	4	4	6	6	7	7	6	6	5,5
41	7	7	6	6	6,5	2	2	6	6	7	6	6	6	5,5
42	7	7	6	6	6,5	7	8	6	6	7	7	6	4	6
43	8	8	6	6	6,5	4	5	6	6	5	3	6	6	5,5
44	8	8	6	6	6,5	2	3	6	6	7	6	6	6	5,5
45	7	7	6	6	6,5	7	7	6	6	8	8	6	6	6
46	8	7	6	6	6,5	3	3	6	6	7	7	6	6	5,5
47	8	8	6	6	6,5	4	4	6	6	7	6	6	6	6
48	8	8	6	6	6,5	2	3	6	6	7	7	6	6	6
49	7	7	6	6	7	1	4	6	6	8	8	6	6	6,5
50	6	7	6	6	6,5	1	6	6	6	6	7	6	6	6
51	7	8	6	6	6,5	4	6	6	6	7	6	6	6	6
52	7	8	6	6	7	4	7	6	8	5	7	6	6	6
53	5	7	6	6	6,5	4	5	6	6	5	5	6	6	6
54	7	8	6	6	6,5	4	5	6	6	8	8	6	6	6
55	5	7	6	6	6,5	4	4	6	6	6	7	6	6	6
56	7	7	6	6	6,5	4	8	6	6	5	5	6	6	6
57	7	7	6	6	6,5	5	8	8	8	6	7	6	6	5,5
58	8	8	6	6	6,5	7	8	6	6	5	5	6	6	6
59	7	7	6	6	6,5	7	1	6	6	7	5	6	6	6,5
60	7	8	6	6	6,5	4	7	6	6	5	5	6	6	6,5
61	8	8	6	6	6,5	5	8	6	6	7	7	6	6	6
62	7	8	6	6	6,5	4	8	6	6	5	5	6	6	6
63	7	8	6	6	6,5	7	7	6	6	8	8	6	6	6
64	8	8	6	6	6,5	4	7	6	6	5	5	6	6	6
65	8	7	6	6	6,5	2	3	6	6	8	7	6	6	6
66	6	6	6	6	6,5	4	4	6	6	8	8	6	6	6
67	7	6	6	6	6,5	4	4	6	6	7	6	6	6	6
68	7	6	6	6	6,5	2	3	6	6	7	6	6	6	5,5
69	8	8	6	6	6,5	7	7	6	6	7	7	6	6	6
70	8	8	6	6	6,5	2	4	6	6	8	8	6	6	5,5
71	7	6	6	6	6,5	5	5	6	6	7	6	6	6	5,5
72	8	8	6	6	6,5	4	4	6	6	6	6	6	6	6
73	8	8	6	6	6,5	2	4	6	6	8	8	6	6	6
74	8	7	6	6	6,5	5	5	6	6	7	6	6	6	6
75	8	7	6	6	6,5	4	4	6	6	6	6	6	6	6
76	8	8	6	6	6,5	4	4	6	6	5	3	6	6	6
77	8	8	6	6	6,5	4	4	6	6	3	1	6	6	6
78	7	7	6	6	6,5	2	3	6	6	8	8	6	6	5,5
79	7	7	6	6	6,5	2	5	6	6	7	7	6	6	6
80	8	8	6	6	6,5	7	8	6	6	8	8	6	6	6
81	6	7	6	6	6,5	4	7	6	6	5	5	6	6	6,5
82	7	8	6	6	6,5	4	5	6	6	6	7	6	6	6
83	7	8	6	6	6	4	5	6	6	5	5	6	6	6
84	5	7	6	6	6	1	3	8	8	5	7	6	6	6
85	7	8	6	6	7	4	7	6	8	7	8	6	8	6,5
86	5	8	6	4	6	4	7	6	6	5	7	6	6	6
87	5	7	6	6	6,5	7	8	6	8	6	7	6	6	5,5
88	6	7	6	6	6,5	4	4	6	8	7	8	6	6	6
89	8	8	6	6	6,5	7	5	6	6	5	5	6	6	6
90	7	7	6	6	6,5	7	6	6	6	6	7	6	6	6
91	7	8	6	6	6,5	5	7	6	6	6	7	6	6	6
92	7	8	6	6	6,5	7	7	6	6	7	7	6	6	6
93	7	8	6	6	6,5	5	7	6	6	6	5	6	6	6
94	7	7	6	6	7,5	7	5	6	6	7	5	6	6	6
95	6	8	6	6	6,5	7	5	6	6	7	7	6	6	6
96	8	8	6	6	6,5	7	7	6	6	3	5	6	6	7

Tabel 4 Classified Data of Train Package on the Bandung-Jakarta Direction

Respondent	TtoU	PoU	SoC	IoC	CoC	TtiU	PiU	SiC	IiC	TtdU	PdU	SdC	IdC	CdC
1	7	8	6	6	5	3	7	6	6	7	8	6	6	6,5
2	6	7	6	6	5	3	7	6	6	7	8	6	6	5,5
3	7	8	6	6	5,5	3	7	6	6	7	6	6	6	5,5
4	7	8	6	6	5,5	3	7	6	6	6	8	6	6	7
5	5	7	6	6	5	3	7	6	6	7	6	6	6	5,5
6	7	8	6	6	6	3	7	6	6	6	8	6	6	6,5
7	1	7	4	4	5,5	3	7	6	6	3	8	6	6	4,5
8	6	7	6	6	6	3	7	6	6	5	7	6	6	6,5
9	6	6	6	4	4,5	3	7	6	6	7	6	6	6	6,5
10	7	7	6	6	6	3	7	6	6	5	8	6	6	5,5
11	5	7	8	8	6	3	7	6	6	7	6	8	8	6,5
12	7	7	6	6	6	3	7	6	6	3	8	6	6	5,5
13	6	8	6	6	6	3	7	6	6	6	8	6	6	6
14	6	7	6	6	5,5	3	7	6	6	5	6	6	4	6
15	7	8	6	6	6	3	7	6	6	7	6	6	6	6
16	5	7	6	6	5	3	7	6	6	3	4	6	6	6
17	5	8	6	6	6	3	7	8	8	6	8	8	8	6
18	7	8	6	6	6	3	7	6	6	5	7	6	6	6,5
19	6	8	4	4	5,5	3	7	8	8	3	8	6	6	6,5
20	6	8	6	6	6,5	3	7	6	6	7	8	8	8	6,5
21	7	8	4	4	5,5	3	7	6	6	7	8	8	8	6,5
22	6	8	4	4	5,5	3	7	6	6	7	8	6	6	6,5
23	8	7	6	6	6	3	6	8	8	5	6	8	8	6,5
24	5	7	8	8	5	3	7	6	6	8	8	4	4	7
25	5	6	6	6	7	3	6	8	8	5	5	4	4	7
26	6	7	6	6	7	3	6	6	6	7	8	8	8	6,5
27	6	8	8	8	6	3	7	6	6	5	3	6	6	7
28	8	8	4	4	5	3	6	8	8	7	8	6	6	7
29	8	8	6	6	5,5	3	7	6	6	8	8	6	6	6,5
30	7	8	4	4	7,5	3	7	8	8	7	8	8	8	8
31	6	5	6	6	5	3	8	6	6	7	6	4	4	7
32	8	8	4	4	6	3	7	6	6	5	8	4	4	6
33	5	7	6	6	5,5	3	7	6	6	5	8	6	6	6
34	6	7	6	6	5	3	7	6	6	5	5	6	6	6
35	7	8	6	6	5,5	3	6	6	6	5	5	6	6	6
36	6	8	6	6	5,5	3	6	6	6	7	7	6	4	5,5
37	6	8	6	6	5	3	6	6	6	5	5	4	6	5,5
38	6	7	6	6	5,5	3	6	6	6	7	7	6	6	6
39	7	8	6	6	5	3	6	6	6	6	8	6	6	5,5
40	7	7	6	6	5,5	2	6	6	6	6	6	6	6	7
41	7	8	6	6	5,5	3	6	6	6	6	7	6	6	7
42	6	8	6	6	5,5	3	7	6	6	3	8	6	6	6
43	7	7	6	6	6	3	6	6	6	6	5	6	6	6,5
44	6	8	6	6	6	3	7	6	6	3	8	6	6	6,5
45	6	7	6	6	5,5	3	8	6	6	7	6	6	6	6
46	6	8	6	6	6	3	8	6	6	5	8	6	6	6
47	5	5	6	6	6	3	7	6	6	6	6	6	6	7
48	5	7	6	6	6	3	7	6	6	6	7	6	6	6
49	7	7	6	6	5,5	3	7	6	6	7	6	6	6	6,5
50	7	7	6	6	5,5	3	7	6	6	8	7	6	6	5
51	6	7	6	6	5,5	3	7	8	8	8	8	6	6	6,5
52	7	8	6	6	5,5	3	7	6	6	7	8	6	6	6
53	5	6	8	8	5	3	7	6	6	8	8	8	8	5,5
54	5	8	6	6	5	3	7	6	6	8	8	6	6	6,5
55	5	7	6	6	5,5	3	7	6	6	5	5	6	6	5,5
56	8	8	4	4	5,5	3	8	8	8	7	6	6	6	6,5
57	8	8	6	6	5,5	3	7	6	6	5	8	4	4	7,5
58	6	8	4	4	5,5	3	7	6	6	5	8	6	6	6,5
59	6	8	6	6	6,5	3	6	6	6	7	8	6	6	7
60	7	7	6	6	5,5	3	7	6	6	7	6	6	6	6,5
61	3	3	6	6	5	3	6	8	8	7	6	6	6	7
62	8	8	6	6	5	3	7	6	6	8	7	6	6	6,5
63	7	8	6	6	6,5	3	7	6	6	7	6	6	6	6
64	8	8	4	4	5,5	3	6	8	8	7	8	8	8	6,5
65	7	7	8	8	5	3	7	6	4	7	6	6	6	6
66	6	8	4	6	6	3	7	6	6	5	8	6	4	6,5
67	7	7	6	6	5,5	3	7	6	6	6	5	6	6	7
68	6	7	6	6	6	3	8	6	6	5	5	6	6	6
69	7	8	6	6	5,5	3	7	6	6	6	8	6	6	6
70	6	8	6	6	6,5	3	7	6	6	5	8	6	6	6
71	5	7	6	6	5,5	3	6	6	6	6	6	4	6	6
72	7	8	6	6	5,5	3	8	6	6	5	8	6	6	6
73	6	8	6	6	6	3	8	6	6	5	5	6	4	6,5
74	7	8	6	6	6	3	6	6	6	6	6	4	6	6
75	5	6	6	6	5	3	6	6	6	6	6	6	4	6
76	5	8	6	6	5	3	7	6	6	5	6	6	6	6,5
77	7	8	6	6	5,5	3	6	6	6	6	7	6	6	6,5
78	7	8	6	6	5,5	3	7	6	6	3	8	6	6	6
79	7	7	6	6	5,5	3	8	6	6	5	8	6	6	6,5
80	5	8	6	6	5,5	3	7	6	6	3	6	6	6	6
81	7	7	6	6	5	3	8	8	8	5	8	6	6	7,5
82	7	7	6	6	5	2	8	8	8	5	8	6	6	6,5
83	6	8	8	8	6,5	3	8	8	8	7	7	8	8	7,5
84	7	7	6	6	5,5	3	8	8	8	7	7	8	8	6
85	8	8	6	6	6	3	7	8	8	8	8	6	6	7,5
86	8	8	6	6	6	3	7	8	8	8	8	6	6	7,5
87	5	6	8	8	6	3	7	8	8	8	6	8	8	7,5
88	8	7	6	6	6	3	7	6	6	8	6	6	6	7,5
89	8	7	8	8	6,5	3	7	8	8	8	8	6	6	6,5
90	8	7	6	6	5,5	3	7	6	6	8	8	6	6	7
91	8	7	6	6	6,5	3	7	6	6	5	8	6	6	6,5
92	8	7	4	4	5,5	5	7	6	6	5	8	4	4	7
93	3	5	8	8	7	2	8	8	8	5	3	8	8	6
94	8	8	6	6	6	3	8	6	6	8	8	6	6	6,5
95	5	7	8	8	6	3	7	8	8	7	5	8	8	6,5
96	8	8	6	6	7	3	7	8	8	6	7	8	8	6,5

Tabel 5 Classified Data of Minibus Package on the Bandung-Jakarta Direction

Respondent	TtoU	PoU	SoC	IoC	CoC	TtiU	PiU	SiC	IiC	TtdU	PdU	SdC	IdC	CdC
1	8	8	6	6	6,5	6	7	8	8	7	8	6	6	7
2	7	8	4	4	7	6	7	8	8	7	8	8	8	6
3	8	8	8	8	6,5	6	7	8	8	7	8	6	6	8
4	8	8	4	4	8	6	7	8	8	7	8	6	6	8
5	8	8	4	6	7,5	3	7	6	6	8	8	8	8	8
6	8	8	6	6	7	5	7	6	6	7	8	6	6	7
7	7	8	8	8	6	3	7	6	6	7	3	6	6	7
8	8	8	6	6	6	5	7	6	6	7	8	6	6	6,5
9	7	8	6	6	7	3	7	6	6	7	6	6	6	7
10	8	8	6	6	6	3	7	6	6	7	8	6	6	7
11	7	8	6	6	6,5	3	7	6	6	7	7	6	6	7
12	7	8	6	6	7	5	7	6	6	7	8	6	6	6,5
13	7	8	6	6	6,5	3	7	6	6	8	8	4	4	7
14	7	8	6	6	7	3	7	6	6	5	7	6	6	7
15	8	8	6	6	6	3	7	6	6	7	8	6	6	7
16	7	8	6	6	6,5	3	7	6	6	7	6	6	6	7
17	8	8	4	4	6,5	5	7	6	6	7	8	8	8	7
18	8	8	4	4	6	5	7	6	6	7	8	8	8	5,5
19	7	8	2	2	7	3	7	6	6	7	8	4	4	7
20	7	8	8	8	7	3	7	6	6	7	6	6	6	7
21	7	8	6	6	7	3	7	6	6	5	3	6	6	7
22	7	8	6	6	7	3	7	6	6	7	8	6	6	7
23	7	8	8	8	7	3	7	6	6	7	6	6	6	7
24	7	8	6	6	6,5	3	7	6	6	7	8	4	4	6,5
25	7	8	8	8	7	3	7	8	8	7	8	8	8	7
26	6	6	6	4	8	3	7	6	6	5	3	6	6	7
27	7	8	4	4	7,5	6	7	6	6	7	8	4	4	6,5
28	6	8	4	4	7	6	7	8	8	7	7	4	4	7
29	5	4	6	6	7,5	6	7	8	8	5	1	8	8	7,5
30	7	8	8	8	7,5	5	7	8	8	7	8	6	6	7,5
31	8	8	6	6	6,5	6	7	6	6	7	6	6	6	7
32	5	5	6	6	7,5	5	7	6	6	5	3	6	6	7,5
33	8	8	4	4	7	3	7	6	6	8	8	6	6	7
34	7	7	6	6	6	1	7	6	6	7	8	6	6	7
35	7	8	6	6	5,5	3	7	6	6	7	8	6	6	6
36	8	8	6	6	7	3	7	6	6	8	8	6	6	7
37	7	8	6	6	6	3	7	6	6	7	8	6	6	7
38	8	8	8	8	7	3	7	6	6	8	8	6	6	7
39	8	8	8	8	6,5	3	7	6	6	7	8	6	6	7
40	7	8	6	6	5,5	3	7	6	6	8	8	6	6	6
41	8	8	8	8	7	3	7	6	6	7	6	6	6	7
42	7	8	6	6	7	3	7	6	6	7	8	6	6	6,5
43	7	8	8	8	7	3	7	6	6	8	7	6	6	7
44	7	8	4	4	6	3	7	6	6	8	8	4	4	7
45	7	7	6	6	6	3	7	6	6	8	8	6	6	7
46	7	8	4	4	6,5	5	7	6	6	8	8	6	6	6,5
47	7	8	6	6	6	3	7	6	6	7	7	6	6	6,5
48	7	8	6	6	5,5	5	7	6	6	8	8	6	6	5,5
49	7	8	6	6	6	3	7	6	6	7	6	8	8	5,5
50	5	8	4	4	6,5	5	7	6	6	8	8	2	2	6,5
51	5	8	4	4	6,5	5	7	6	6	8	7	6	6	6
52	6	8	8	8	7	6	7	8	8	6	8	8	8	7
53	7	8	6	6	5,5	3	7	6	6	6	8	8	8	7
54	7	8	8	8	6	3	7	8	8	7	8	8	8	6,5
55	6	1	6	6	6	6	7	8	8	7	3	6	6	7
56	7	7	6	6	5,5	2	7	6	6	7	6	6	6	6,5
57	8	7	6	6	6	3	7	8	8	7	6	6	6	7
58	8	8	6	6	6,5	3	7	6	6	8	8	4	6	6,5
59	7	8	8	8	7	3	7	4	8	8	8	6	2	8
60	5	6	6	6	6,5	8	8	6	6	7	6	6	6	6,5
61	7	8	4	6	7	8	7	6	6	5	8	4	4	6
62	8	8	6	6	6,5	3	7	6	6	8	8	4	4	6,5
63	5	7	6	6	6,5	3	7	6	6	8	8	6	6	7
64	7	8	6	6	6	3	7	6	6	7	8	6	6	6
65	7	8	6	6	7	5	7	4	4	5	7	6	6	6,5
66	7	8	6	6	7	3	7	6	6	5	7	6	6	7
67	7	8	6	6	6	3	7	6	6	7	8	6	6	7
68	8	8	6	6	5,5	3	7	6	6	7	7	6	6	7
69	7	8	4	4	7	6	7	6	6	7	8	4	6	7
70	7	7	8	8	7,5	1	7	8	8	8	8	8	8	7
71	7	8	8	8	6,5	3	7	8	8	7	8	4	6	6,5
72	7	8	6	6	5,5	3	7	6	6	7	8	6	6	7
73	8	8	6	6	5,5	3	7	6	6	8	7	6	6	6
74	8	8	6	6	7	3	7	6	6	8	7	6	6	6,5
75	7	6	6	6	6	3	7	6	6	8	8	6	6	6,5
76	8	8	6	6	5,5	3	7	6	6	7	7	6	6	7
77	8	8	6	6	6	3	7	6	6	8	7	6	6	7
78	7	8	6	6	6	3	7	6	6	7	8	6	6	7
79	7	8	6	6	5,5	3	7	6	6	6	8	6	6	6,5
80	7	8	6	6	6,5	3	7	6	6	7	8	6	6	6
81	7	7	8	8	7,5	1	7	8	8	8	8	8	8	7
82	7	8	8	8	6,5	3	7	8	8	7	8	4	6	6,5
83	8	8	6	6	6,5	3	7	6	6	8	8	4	4	6,5
84	7	8	4	6	7	8	7	6	6	5	8	4	4	6
85	5	6	6	6	6,5	8	7	6	6	7	6	6	6	6,5
86	7	7	6	6	6	1	7	6	6	7	8	6	6	7
87	7	7	6	6	6,5	3	7	6	6	7	6	6	6	6,5
88	7	8	6	6	6	2	7	6	6	7	8	6	6	6,5
89	8	8	6	6	6	2	7	6	6	7	6	6	6	5,5
90	7	7	6	6	6	3	7	6	6	1	6	6	6	6,5
91	7	8	6	6	6,5	6	7	6	6	7	8	6	6	6
92	7	7	6	6	6	3	7	6	6	7	7	6	6	6
93	7	8	8	8	7	3	7	6	6	8	7	6	6	6
94	8	8	8	8	6,5	3	7	6	6	7	8	6	6	6
95	8	8	8	8	6	3	7	6	6	8	8	6	6	6
96	7	7	6	6	6	3	7	6	6	8	8	6	6	6

Tabel 6 Classified Data of Car on the Bandung-Jakarta Direction

Respondent	TtoU	PoU	SoC	IoC	CoC	TtiU	PiU	SiC	IiC	TtdU	PdU	SdC	IdC	CdC
1	7	8	6	6	6	3	7	6	6	7	8	6	6	7
2	8	8	6	6	6	6	7	6	6	7	8	6	6	7
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