UNIVERSITY OF SOUTHAMPTON

FACULTY OF ENGINEERING AND THE ENVIRONMENT

Civil, Maritime and Environmental Engineering and Science

Improving Quality of Rail Service in Kuala Lumpur, Malaysia

by

Siti Nurbaya Binti Ab. Karim

Thesis for the degree of Doctor of Philosophy

in Civil Engineering and Environment

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ABSTRACT

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The only national heavy commuter train system in Malaysia, called *KTM Komuter,* plays a major role in providing long journey rail-based public transport services to people from urban to suburban areas within the Klang Valley. Since its first operation in the mid-1990s, *KTM Komuter* has had the primary function of alleviating the negative impacts of car use, namely congestion and the associated environmental pollution. However, there are also issues of public transport users overcrowding circumferential links, railway stations, rail cars, bus stops and feeder buses, particularly during peak hours. As a result there is challenge of quality for *KTM Komuter* services with respect to capacity, service frequency, accessibility, connectivity, mobility, on board crowding and station service quality. This has resulted in this thesis examining the *KTM Komuter*'s level of service and overall service quality as perceived by the passengers. It hence aims to determine the optimal levels of *KTM Komuter* provision in terms of quantity and quality of service in an economical manner.

To achieve this aim, several objectives of this research have been identified. The first is to model the travel behaviour of *KTM Komuter* users based on the Origin-Destination (O-D) survey results which will then attempt to demonstrate the practical values of the Generalised Journey Time (GJT) and Generalised Travel Cost (GTC) of the *KTM Komuter* operations. The second objective is to explore and identify the passengers' daily personal perceptions, experiences, needs and situational influences of service quality attributes that best define a high quality rail service based on the factor analysis of the variables of service quality (based on Attitudinal surveys). The third is to evaluate service quality in the *KTM Komuter* systems by developing empirical, statistical models that will be called KOMIQUAL models to determine which of these variables have the greatest impact on *KTM Komuter's* quality of service for a network of routes/corridors. The fourth research objective estimates the mean, median, maximum and minimum *KTM Komuter* passengers per hour for seven time periods based on the Passenger Boarding and Alighting survey results and to gauge optimal headway, optimal fleet size, optimal vehicle capacity and optimal pricing based on an Economic Optimization approach. The number of *KTM Komuter* train sets will be examined using the ROMAN-D software based on both the actual and design operating service frequencies. As a result, a better *KTM Komuter* Timetable and Public Timetable will be identified. Finally, policy recommendations are proposed to improve the quality of services of the *KTM Komuter* system.

The key results of the O-D surveys depicted that there were high possibilities for Non-Motorized Transport (NMT)-Public Transport (PT) Integration with mode splits of 21% walk-and 40% PT for access and 39% walk and bicycle and 32% PT for egress. The corresponding mean access and egress travel distances including Walking and PT were 15.0 km and 13.1 km. respectively. The resulting values of the GJT and

GTC were high suggesting the importance of these determinants in deterring passengers from choosing *KTM Komuter* as a main transport mode.

For the results of the Attitudinal surveys, both the overall service quality and level of service were mostly rated as being fair by the *KTM Komuter* passengers. Improving parking facilities, increasing train efficiency, people services and space comfort were the main components out of nine input components (which also included train ambience, ticketing, information and station entry-exit systems, station quality, facilities, and rail structures) in the KOMIQUAL models that best defined high quality *KTM Komuter* service among *KTM Komuter* users.

The values of mean, median, maximum and minimum *KTM Komuter* passengers per hour for seven time periods differed widely. The optimal fleet size, optimal vehicle capacity and optimal pricing resulted in two categories of peak period for KL Inbound namely 0630 – 1230 and 1630 – 2130 and these should be designed with the highest fleet sizes of approximately 28 and 21 respectively. Three categories of peak period for KL Outbound were noted namely 0630 – 0930, 1000 - 1300 and 1600 – 2100 and these should be designed with the highest number of fleet size of 28, 26 and 33 respectively. A capacity of up to 249 seats per train, including standees, should be provided for outbound services 1600 – 2100. By contrast, a capacity of up to 161 seats per train, including standees, should be provided for inbound services 0630 – 1230.

The average value of the total optimal price is reported to be RM1.83. These average values of the total optimal price for both directions are found to be slightly lower than the yields or average fares per boarding from 2008 to 2013 ranging from RM1.90 in 2011 to RM2.40 in 2013. There will be no more fare reduction in future as the existing fares are considered quite cheap and new *KTM Komuter* fares for the Klang Valley sector should be structured based on the current rate of fare (or operating cost per day per passenger-km) of RM0.21.

These models produced optimized service patterns (train frequency and capacity) and fares. A practical operating service headway should be 10 minutes during 0500 – 1630 hours and 15 minutes during 1630 – 2235 hours for both ways. Based on the findings, the conclusions are to improve the overall services of *KTM Komuter*. The implications are to define the interactions of *KTM Komuter*'s demand and supply in regard to a trade-off between economically efficient operation and adequate quality of service for the public which are very complex and require detailed analyses and decisions. Some of the policy recommendations to improve the quality of services of the *KTM Komuter* system include defining the future role for the *KTM Komuter* system, innovating *KTM Komuter* Business and regulating *KTM Komuter* services.

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DECLARATION OF AUTHORSHIP

I, Siti Nurbaya Binti Ab. Karim

declare that this thesis and the work presented in it are my own and has been generated by me as a result of my own original research.

Improving Quality of Rail Service in Kuala Lumpur, Malaysia

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
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Signed:

Date: 25th. January 2016

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DEFINITIONS AND ABBREVIATIONS

A survey	Attitudinal survey
AFC	Automatic Fare Collector
AMOS	Analysis of Moment Structures
ANOVA	Analysis of Variance
AON	All-Or-Nothing
API	Air Pollution Index
APIMS	Air Pollutant Index Management System
ART	Advanced Rapid Transit
ASEAN	Association of Southeast Asian Nations
ATMs	Auto Teller Machines
AVE	Average Variance Extracted
BERNAMA	Berita Nasional Malaysia (Malaysian National News Agency)
CBD	Central Business District
CFA	Confirmatory Factor Analysis
CR	Construct Reliability
ECR	Extended Contributive Rule
EFA	Exploratory Factor Analysis
ERL	Express Rail Link
ERLSB	Ekspres Rail Link Sdn. Bhd.
FTKL	Federal Territory of Kuala Lumpur
GBP	Great Britain Pounds

GDP	Gross Domestic Product
GIS	Geographical Information System
GJT	Generalised Journey Time
GPS	Global Positioning System
GTC	Generalised Travel Cost
HNDP	Highway Network Development Plan
IC	Identity Card
ITIS	Integrated Transport Information System
ITS	Intelligent Transport System
ITT	Integrated or Intermodal Transport Terminal
JICA	Japan International Cooperation Agency
KL	Kuala Lumpur
KLC	Kuala Lumpur and its Conurbation
KLCAT	Kuala Lumpur City Air Terminal
KLCC	Kuala Lumpur City Centre
KLCUR	Kuala Lumpur Core Urban Region
KLIA	Kuala Lumpur International Airport
KLMA	Kuala Lumpur Metropolitan Area
KLMR	Kuala Lumpur Metropolitan Region
KLS	Kuala Lumpur Sentral
KLSS	Kuala Lumpur Sentral Station
KRTS	Kaohsiung Rapid Transit System
KTMB	Keretapi Tanah Melayu Berhad (Malaysian Railway Limited)
KVC	Klang Valley and its Conurbations
KVPT	Klang Valley Public Transport
LOS	Level of Service

LOTS	level of transport service
LTA	Land Transport Authority of Singapore
MIROS	Malaysian Institute of Road Safety Research
MITRANS	Malaysia Institute of Transport
MLS	Maximum Load Section
MRR	Middle Ring Road
MSC	Multimedia Super Corridor
MT	Motorized Transport
MURs	Mega-Urban Regions
MUST	Malaysia University of Science and Technology
MYR	Malaysian Ringgit
NKRA	National Key Result Areas
NMT	Non-Motorized Transport
O	Other
O-D	Origin-Destination
OSQ	Overall Service Quality
PASW	Predictive Analytics Software
PCA	Pedestrian Catchment Area, Principal Component Analysis
PDFH	Passenger Demand Forecasting Handbook
PEMANDU	Performance Management and Delivery Unit
PETRONAS	Petroleum Nasional Berhad
PM_{10}	Suspended Microparticulate Matter
PT	Public Transport
PTOD	Public Transport Oriented Development
PUTRA LRT	Projek Usahasama Transit Ringan Automatik Sdn. Bhd.
QOS	Quality of Service
RapidKL	Rangkaian Pengangkutan Integrasi Deras Sdn. Bhd.

RP Survey	Revealed-Preference Survey
SCR	Simple Contributive Rule
SEM	Structural Equation Modelling
SMURT	Study on Integrated Urban Transportation Strategies for Environmental Improvement
SP Survey	Stated-Preference Survey
SPNB	Syarikat Prasarana Negara Berhad
SPSS	Statistical Package for the Social Sciences
SQ	Service Quality
SQM	Service Quality Management
STAR LRT	Sistem Transit Aliran Ringan Sdn. Bhd.
TCQSM	Transit Capacity and Quality of Service Manual
TCRP	Transit Cooperative Research Program
TOD	Transit-Oriented Development
TRANSIT	The Association for the Improvement of Mass Transit
TRB	Transportation Research Board
TSI	Transit Service Indicator
TU	Transit Unit
TVMs	Ticket Vending Machines
UiTM	Universiti Teknologi MARA
UKM	Universiti Kebangsaan Malaysia (National University of Malaysia)
VoT	Value of Time
WebTAG	Web Transport Analysis Guidance
WTP	Willingness To Pay

CHAPTER 1 : INTRODUCTION

This chapter presents the demand for KL public transport which has been on a decline since the mid-1980s due to inadequate and unplanned public transport services and network coverage together with lack of control on the production and sales of private cars as highlighted in the subsequent sections in the background of the study and problem statements. There are also issues pertaining to sub-optimal rail-feeder bus performance and safety because of sub-optimal public transport integration and sustainability in the Klang Valley as well as no proper associated transport guidelines and policies at national and state levels. In line with the objective (focus) or scope of this research, the government should aim to guarantee optimal *KTM Komuter* supply in a cost-effective way in order to fulfil the increasing demand and revenue from the general population. Several hypotheses are tested to encourage research efforts in improving the current *KTM Komuter* services based on the perspective of passengers. The detailed contents of this thesis are structured systematically under Subheading 1.7 or the Organization of the thesis.

1.1 BACKGROUND

Minibuses had been the most popular mode of public transport for three decades since 1960 (Rohana et al., 2012). Between 1985 and 1997, the modal share of public transport in Malaysia decreased from 34.3% to 19.7%. This figure dropped further to 16.0% in 2003 and remained consistent until 2007. Rail services represented 10% out of 16% of the KL public transport modal split in 2003 (Norlida et al., 2006, Hossain, 2007). Utilisation of stage buses/minibuses continued to decrease and represented only 6.0% of the entire transport system (Hossain, 2007). This depicted a major shift in the mode of transportation in public transport and in particular bus transport, which was partly attributable to higher personal affluence leading to an increase in car ownership, car usage and trips (Townsend, 2003, Rozmi et al., 2013). In the meantime, there were also deficiencies in the bus services primarily as a consequence of route duplication, unreliable service frequency, and overcrowding during peak hours. Currently, the total number of registered motor vehicles in Malaysia is approximately 18 million. The number of registered motor vehicles in Malaysia has increased fourfold in a 22-year period (from 1990 to 2011) where Malaysia took the lead in 311 car ownerships per 1000 people in 2010 (Chuen et al., 2014). Chuen et al. (2014) stressed that the development of roads, highways and parking facilities experienced limited growth in the Klang Valley due to land scarcity. The increasing reliance on private transportation, in particular private cars has increased chaos on the road network and infrastructure system, which has then contributed to critical problems of vehicular traffic congestion (Hull, 2005), the associated environmental pollution (Rozmi et al., 2013, Pronello and Camusso, 2011, Lai and Chen, 2011, Kingham et al., 2001, Homem de Almeida Correia et al., 2013, de Oña et al., 2012, Chuen et al., 2014, Khoo and Ong, 2015, Monchambert and de Palma, 2014, Buehler and Pucher, 2011, Grotenhuis et al., 2007) and limited parking areas (Kamba et al., 2007), health impacts (Hine, 2000), social problems (Buehler and Pucher, 2011), noise (Grotenhuis et al., 2007; Román and Martín, 2011), global warming (Potter and Skinner, 2000; Hine, 2002; Buehler and Pucher, 2011; Muhamad Nazri et al., 2014)(Jain et al., 2014), damaged towns (Hine, 2002) and public transport users overcrowding circumferential links railway stations, inside rail cars (Nor Diana, 2012, Tukis and Nizamuddin, 2012), bus stops and feeder buses

(Tirachini et al., 2013, Frost et al., 2012), particularly in urban areas (Chuen et al., 2014) like Kuala Lumpur and Selangor. The increasing reliance on private cars had also worsened accessibility in and around big cities in Malaysia as a consequence of typical traffic jams and haphazard parking (Muhamad Nazri et al., 2014). The average speed of cars is less than 10 kph in frequent jams (Muhammad Akram, 2007; Kingham et al., 2001; Khoo and Ong, 2015). This phenomenon has adversely affected the efficiency of urban public transport in terms of average travel speed and average travel time of the bus, *per se* (Siti Nurbaya, 2003) and the safety performance of urban private transport (Potter and Skinner, 2000; Grotenhuis et al., 2007; Buehler and Pucher, 2011; Jain et al., 2014) in the Klang Valley (Kamba et al., 2007; Khoo and Ong, 2015), thus obstructing regular operations. The overdependence of cars and low usage of public transport in the Klang Valley were induced by insufficient (Hull, 2005; Grotenhuis et al., 2007; Kamba et al., 2007) and unplanned public transport systems (Chuen et al., 2014).

Realizing that the alarming congestion is common to most road users in an urban setting (Muhammad Akram, 2007, Homem de Almeida Correia et al., 2013), several planners, engineers, architects and even policy-makers started noticing the important role of public transport in reducing traffic congestion (Rohana et al., 2012); particularly that of rail transport services together with the feeder service (Gärling and Axhausen, 2003; Syahriah et al., 2013) so as to efficiently, effectively, safely and economically increase rapid mobility (Eboli and Mazzulla, 2012, Suria, 2012, Xie et al., 2009, Tsai et al., 2013, Chuen et al., 2014) and accessibility (Syahriah et al., 2013). This rapid mobility is due to increased speed (Feng, 2011; Tsai et al., 2013). Although rail rapid transit technology and systems are costly, they provide an exclusive facility aiming at increasing ridership (Mohammad, 1989, Koh et al., 2011, Frost et al., 2012, Lai and Chen, 2011, Givoni and Rietveld, 2007). However, the existing services may have had flaws. The flaws identified were that the systems and facilities of the interchanges (transfers) were not well integrated at stations (Hossain, 2007), and this included car and motorcycle parking and pedestrian linkages (Zulina, 2003). Pedestrian facilities were also not weather-proof and safe (Hossain, 2007), and there was lack of connectivity between rail-based stations (Zulina, 2003, Norlida et al., 2006, Hossain, 2007, Jamilah and Amin, 2007, Department of Railways Malaysia, 2009). In other words, the connectivities between different lines were poor due to inadequate integration (Syahriah et al., 2008; 2013; Rohana et al., 2012) (refer to Figure 1.1). That was why many stations had hardly any people in them. Such examples can be obtained from the ridership data by RapidKL (2012), short for *Rangkaian Pengangkutan Integrasi Deras Sdn Bhd* (refer to Figures 1.2 and 1.3), the ridership data by ERLSB (2009), short for *Ekspres Rail Link Sdn. Bhd.* (refer to Figure 1.4) and the research by Syahriah et al. (2013) which reported that many *KTM Komuter* stations serve low populated areas with limited pedestrian activities because they were not located in high density residential and commercial areas that potentially generate captive riders. Another research by Syahriah et al. (2008) also reported on the lack of integration on the information provisions for rail-bus modes in Malaysia that resulted in lack of confidence among passengers for such systems. This was due to the fact that rail-bus information in 2007 was restricted to scheduled departure and arrival time and the messages were simply conveyed without taking into consideration if passengers comprehended them.

In 2011, Masjid Jamek experienced ridership at 14.2% and this increased slightly to 14.7% for the first six months of 2012 (Figure 1.2). Kuala Lumpur City Centre (KLCC) station witnessed a very minimal decrease in ridership in 2012 (13.5%) compared to 2011 where ridership stood at 13.6%. KLS station had in 2012 (the first six months) an increase in ridership compared to 2011 (12.2% compared to 10.9%). Other 21 stations showcased less than 10.0% in ridership each for 2011 and 2012, respectively.

The Ampang/Sri Petaling Line Masjid Jamek experienced a minor or minimal increase in ridership (Figure 1.3). In 2011 the ridership percentage stood at 13.4% and in 2012, 18.1% (for the first six months). In Hang Tuah, ridership decreased in the first six months of 2012 to 8.5% from 9.4% in 2011. The other 23 stations witnessed a very minimal decrease in the first six months of 2012 at less than 8.5% compared to less than 9.4% in 2011.

In the KLIA Transit, the following percentages were seen in ridership (refer to Figure 1.4): Salak Tinggi - 11.5% in 2008 compared to 11.1% for the first three months of 2009; Bandar Tasik Selatan - 13.3% in 2008 compared to 13.7% for the first three months of 2009; Kuala Lumpur Sentral (KLS) station saw no drastic increase but a mere 0.1% in 2009 (the first three months) compared to 24.9% in 2008. Finally, the percentages for Putrajaya/Cyberjaya and Kuala Lumpur International Airport (KLIA) stations ridership from 2008 compared to the first three months of 2009 increased (by 1.2%) and decreased (by 1.2%), respectively.

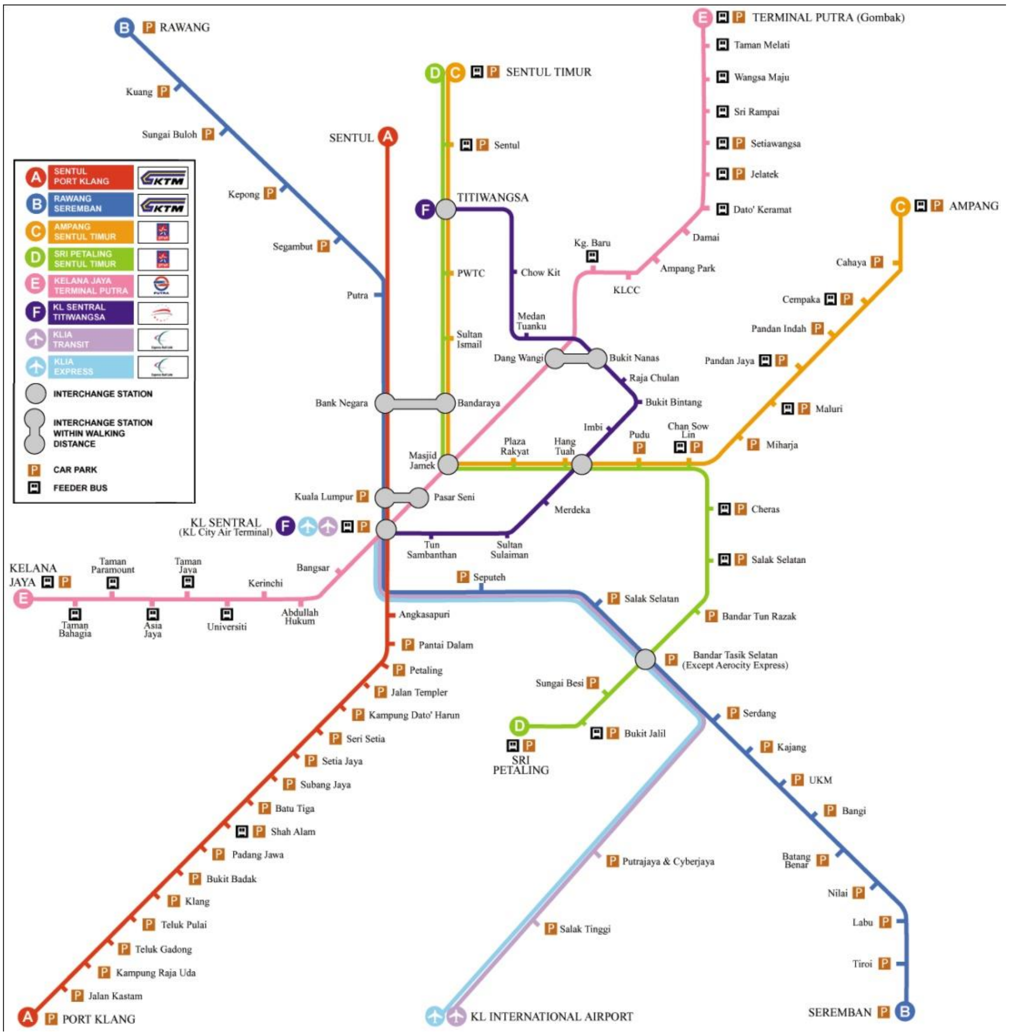

Figure 1.1 A Route Map of the Various Railway Lines and Stations in KL

<u>Source: anjungkl.com</u>

RapidKL is the operator of two light rail transit (LRT) lines, the largest stage bus and feeder bus service in Kuala Lumpur, and, as of November 2007, the single line of the KL Monorail and parts of the KLIA Transit route. Thus, traffic engineers experienced challenging tasks. Firstly, to correctly design the quality of the operational, environmental, financial and safety performance of the rail transit-feeder bus systems and secondly, to properly and rationally analyze the corresponding rail traffic capacity to be able to forecast rail demand. With this moderate expansion of rail network, it is timely to observe the operations and management of existing stations to establish measures that suit the changing needs/environment.

Sustainable transportation has become a leading factor thus explaining the planning initiatives to develop urban transportation infrastructure as part of the more effective integrated strategies within urban mobility management particularly in the UK (May and Roberts, 1995; Hine et al., 2000; Potter and Skinner, 2000; Kingham et al., 2001; Hine, 2002; Hull, 2005; Muhammad Faishal, 2003; Preston, 2010; 2012a; Cao, 2013; Deutsch et al., 2013; Nurul Habib and Zaman, 2012; Frost et al., 2012; de Oña et al., 2012; Syahriah et al., 2013; Chowdhury et al., 2014). Accordingly, this necessitates specific designs and analysis guidelines to ensure that professional judgments and decisions are made complying sustainable requirements. These include having good design features combined with management measure, taking into account public transport-oriented development, urban mode choice behaviour of inhabitants, the economic and social aspects and environmentally- (May and Roberts, 1995; Too and Earl, 2010) and user-friendly facilities (Ahern and Anandarajah, 2008, Nurul Habib and Zaman, 2012). In fact, the fullest commitment and allocation of resources could address sustainability issues in the UK (Potter and Skinner, 2000). Too and Earl (2010), Rohana et al. (2012) and Khoo and Ong (2015) opined that a sustainable transport system can lessen the adverse impacts of environment and social woes due to its role towards environment protection, as well as the economy and social aspects. An example was given by the 1998 UK transport white paper as stated in Hull (2005) along with Hine (2002), Preston (2012a) and Redman et al. (2013) who all agreed that the integrated public transport could and can reduce environmental impact and encourage greater use of public transport, walking and cycling.

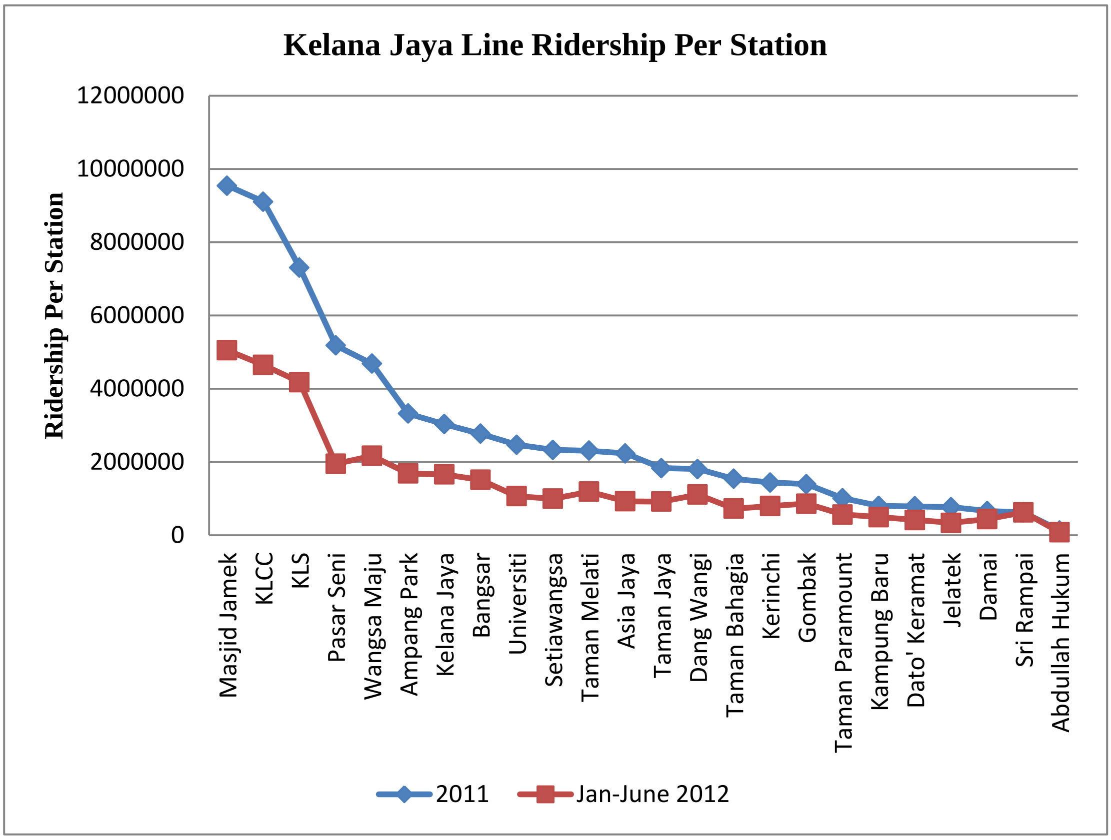

Figure 1.2 Kelana Jaya Line Ridership Per Station

<u>Source: RapidKL (2012)</u>

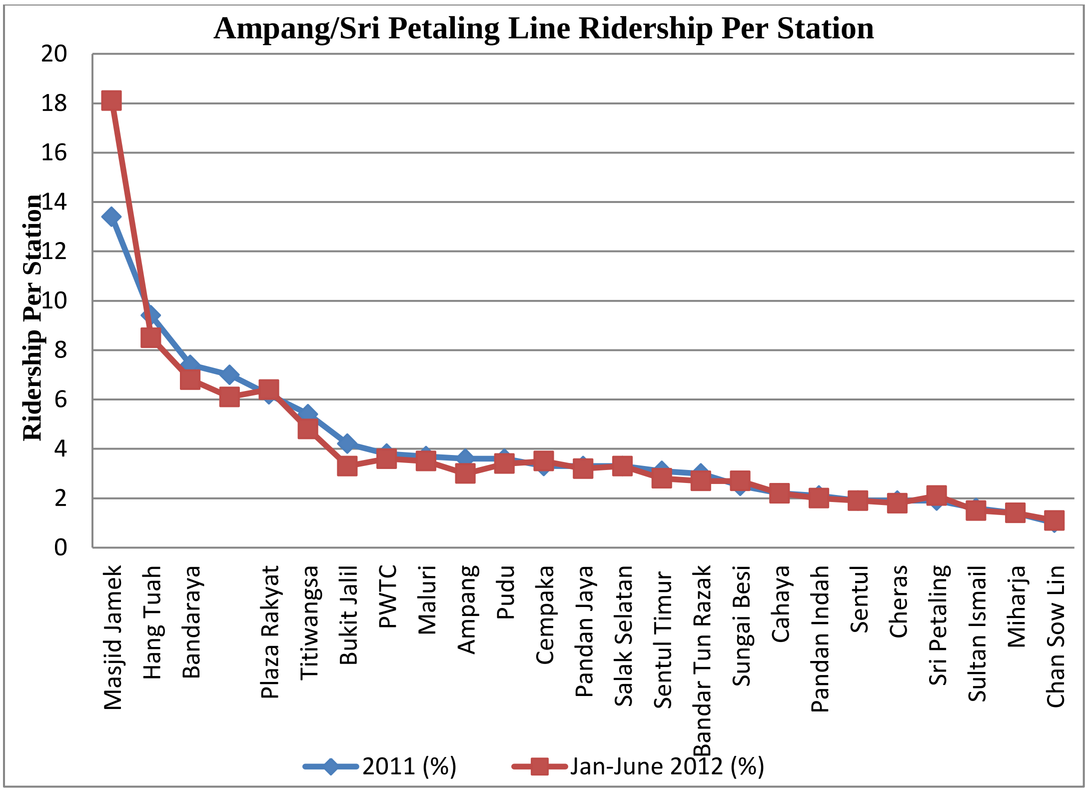

Figure 1.3 Ampang/Sri Petaling Line Ridership Per Station

Source: RapidKL (2012)

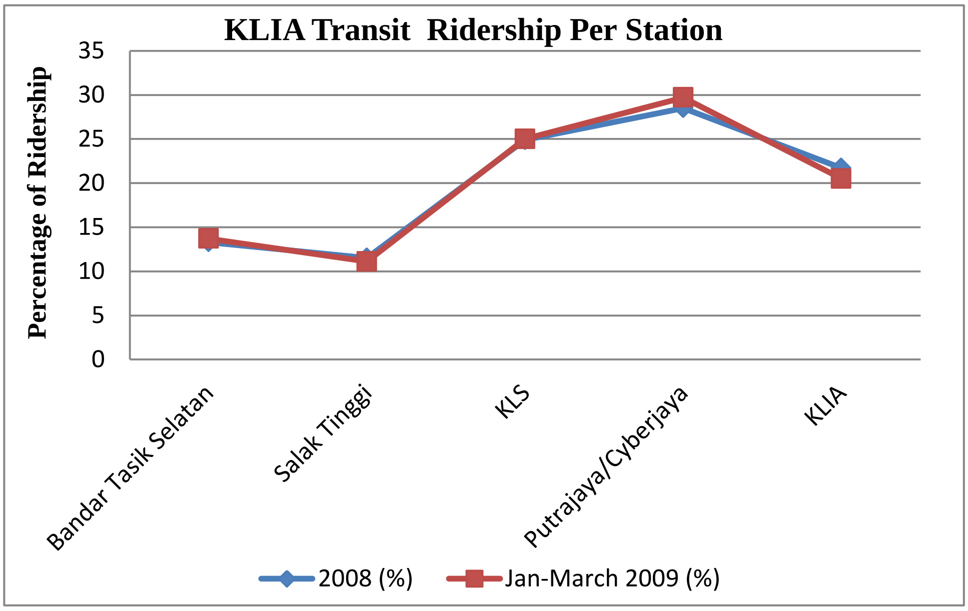

Figure 1.4 KLIA Transit Ridership Per Station

Source: ERLSB (2009)

The study aims to determine the optimal levels of rail provision in terms of quantity and quality of service in an economical manner (Nash, 2000, Litman, 2007-2015) where it is designed to practically integrate and effectively optimize the public transport system planning and network design management. The study formulates and evaluates empirical models based on the Kuala Lumpur rail and rail users' conditions with the absence of the Malaysian Public Transport Capacity and Quality of Service specification (Nor Diana, 2012). No special committee can produce this specification due to lack of transport and traffic experts in Malaysia. Empirical studies are required to analyze the impacts of number of trains and train size (especially its length) along the entire operation of rail and bus systems, combined. Correct, accurate and practical estimation of door-to-door travel time is extremely important for every transportation planner, engineer, modeller, analyst and even public transport operator and policy-maker in order to plan, design, operate and maintain an effective and reliable public transport system. A typical door-to-door total travel time of passengers is precisely measured in terms of time spent in-vehicle and the time spent waiting, walking and transferring (Mohammad, 1989, Reinhold and Kearney GmbH, 2008). In quantifying travel time values, generalized costs are often evaluated in transport models comparable to effective speed. On the whole, generalized travel costs are defined as the combined time and financial costs during travelling. The implication of modifying effective speed (or social speed) involves higher operating and maintenance costs and overheads for more expensive modes (Litman, 2007). Theoretical models of total social cost (TSC) will be developed using the classic calculus method prior to formulating and optimizing them. These steps are very much relevant to target optimal end solutions. Bussieck et al. (2004) and Borndörfer et al. (2007) proved that computational progress of transport modelling can lead to an integrated treatment of most of the public and rail transport planning and design network problems.

1.2 PROBLEM STATEMENTS

Theoretically, rail transit systems have proven to be the highest hierarchy system of public transport. With an appropriate average running speed and average running time, rail transit systems can significantly provide maximum comfort, convenience and safety to passengers. Miscalculated designated running time will result in undesirable operations at certain corridors. Longer average running time, for example, will prompt longer average waiting time, including stopping/starting time which are part of the boarding/alighting time at stops) (Jansson, 1984, Daamen, 2004).

The effect of demand over-estimation is a shortage of revenue. The normal procedure to overcome this is first to withdraw vehicles (Sugawara, 1995, Topp, 1999, Tan, 2008), and then limit maintenance. Initially, this will lead to a loss of service quality, and ultimately loss of quantity as vehicles are subjected to wear and tear. This can jeopardise the entire operation of the route network. In the Malaysian context, Mohammad Ali et al. (2006) asserted that the national planning studies undertaken by a few local authorities in the past recommending low rail connectivity within the Klang Valley especially for regional travelling be looked into. Therefore, it is not surprising that traffic engineers are required to periodically analyze the network design features and its operational quality in terms of efficient performance (Pronello and Camusso, 2011) of a fixed route network of public transport. This is because Rozmi et al. (2013) have drawn attention to the fact that public transport network is so meaningful to the megacities of the world that a sustainable network should provide easy and direct access and, likewise, cheaper cost to users. In addition to that, one good point highlighted by Mohammad Ali et al. (2006) regarding achieving efficiency of land use is maximizing access between residential areas and service. Public transport network design improvements have also garnered immense interest among many researchers around the world for their real-world applications (Ortuzar and Willumsen, 2001, Desaulniers and Hickman, 2007, Caprara et al., 2007, Cordeau et al., 2007, Crainic and Kim, 2007, Marcotte and Patriksson, 2007, Muhammad Akram, 2007, Suria, 2012, Gallo et al., 2011, Frost et al., 2012).

To date there has been no research for the Malaysian rail transport system condition with regard to operations. There has also been no Non-Motorized Transport (NMT) research carried out or attention given in this area in the Malaysian context as compared to motorized transport. The absence of a specific guideline at national level has caused traffic planners and engineers to primarily estimate both capacity and demand based on their own professional judgment (Kasem, 2003, Muhammad Akram, 2007). They are probably unclear in deciding and identifying the parameters for estimating the basic performance measures of rail transport (Kasem, 2003; Gallo et al., 2011; Daly et al., 2012) before anticipating rail capacity, hence, impacting its quantity and quality of service.

Deciding and identifying the parameters is crucial to optimize the current network of rail-feeder bus services. Another factor that has not been sufficiently addressed in the planning and designing the rail operation is how both users and potential users perceive the entire rail-feeder bus services (Ortuzar and Willumsen, 2001; Gallo et al., 2011). The feeder bus service of RapidKL had been negatively impacted from inherent system problems (Zulina, 2003; Hossain, 2007) which include:

(a) improper route alignment;

(b) improper design of route capacity;

(c) low frequency due to mixed traffic jam;

(d) incorrect estimation of the actual origin-destination (O-D) pattern; and

(e) inadequate and unsafe passenger access.

Between 2003 and 2012, some positive measures were undertaken such as restructuring the trunk and feeder route, implementing city circle service, introducing an integrated ticketing system and acquiring more buses and rail cars.

Rail usage has been encouraging where the annual riders of Kelana Jaya and Ampang/Sri Petaling LRT lines recorded about a 230.2% (3.3 times) and 129.7% (2.3 times) increase respectively from 1999 to 2007. *KTM Komuter* achieved approximately a 488.3% (5.9 times) increase from 1999 to 2008 whereas the KL Monorail recorded an increase of around 589.3% (6.9 times) from 2003 to 2007 as shown in Table 1.1 and Figure 1.5, respectively. The average daily passengers of Kelana Jaya and Ampang/Sri Petaling LRT lines recorded about a 204.2% (3.0 times) and 40.9% (1.4 time) increase from 1999 to 2001, respectively as shown in Figure 1.6; rail services recorded roughly 10% out of 16% of the KL public transport modal split 2003 as seen in Figure 1.7; and Figure 1.8 which resulted in average daily riders of Kelana Jaya and Ampang/Sri Petaling LRT lines attaining about a 16.2% (1.2 time) and 39.8% (1.4 time) increase from 2001 to 2005.

KTM Komuter achieved an approximately 44.1% (1.4 time) increase whereas KL Monorail recorded around a 90.9% (1.9 times) increase between 2003 and 2005; In contrast, rail services decreased to 1.7% of the national mode share of passenger transport in the re-conduct of the Phase 1 of the Highway Network Development Plan (HNDP). This study was done by the Highway Planning Unit of the Ministry of Works, Malaysia in 2005, and optimal quality of services has yet to be achieved due to issues relating to safety and main performance on the national agenda as mentioned below (Department of Railways Malaysia, 2009, Malaysian Institute of Road Safety Research, 2009, Frost et al., 2012) :-

(a) There is still very low frequency (inadequate number of trains and coaches for all rail transport systems except for KLIA Ekspres; not quite 'real time', however; the interval times were fixed, reliability low, and these impacted waiting time);

Real time here refers to real time information that will show users when a train is due to arrive at the station so that the user can plan his/her journey more accurately.

(b) There is still inadequate network coverage [impact access (Keegan and O'Mahony, 2003) and egress time, i.e., unreliable railway timetable, which required rescheduling of *KTM Komuter* trains over other lines to reduce traffic density on lines or parts of the network and redesigning of the system running speed by speed fleeting the train paths on the timetable on double track lines (Pachl, 2004)] and integration (Rohana et al., 2012); Double lines are currently aligned in the Klang Valley and from Ipoh to Rawang whereas no single line can be found within the Kuala Lumpur Core Urban Region (KLCUR) [i.e., the Federal Territory of Kuala Lumpur (FTKL) and districts of Selangor];

(c) There is inadequate capacity (crush capacity on all systems except for KLIA Ekspres) or under-design railway track capacity based on the Government Transformation Programme, GTP 1.0 Improving Urban Public Transport (Performance Management & Delivery Unit, PEMANDU 2011, accessed on July 9, 2014);

(d) There is low quality of trains (poor condition due to mechanical and operational faults such as technical glitches which have caused trains on the Kelana Jaya LRT line to slow down to a crawl) and substandard stations (under-designed passenger capacity for *KTM Komuter* being inadequate and, resulting in overcrowding especially during peak hours, extreme and constant delays, low maintenance and rehabilitation works and insufficient aesthetic items); In the local scenario evaluated by Syahriah et al. (2013), overcrowding and extreme and continual delays have led to discomfort and inconvenience to passengers (Hale and Charles, 2009).

Table 1.1 Rail Passengers based on Population Growth in FTKL

Year	Population in FTKL	Kelana Jaya Line	Sri Petaling /Ampang Line	KL Monorail	KLIA Ekspres	KLIA Transit	KTM Komuter
1995	1,331,629						2,817,443
1996	1,360,200						11,094,551
1997	1,380,000						14,578,704
1998	1,431,600	1,528,884	18,100,102				20,803,363
1999	1,415,000	17,252,259	22,829,543				17,168,074
2000	1,423,900	44,542,496	28,426,201				19,154,197
2001	1,452,378	52,478,951	32,412,191				20,928,816
2002	1,470,000	54,423,246	33,471,344		1,048,201	187,848	22,084,124
2003	1,352,000	50,254,365	41,159,817	3,220,297	1,697,574	970,598	24,645,493
2004	1,518,200	57,729,971	43,535,471	12,201,518	1,912,340	1,734,614	27,380,423
2005	1,620,100	60,290,467	45,636,997	16,206,441	1,604,404	1,829,224	30,934,651
2006	1,695,157	56,747,136	49,727,909	19,322,170	1,838,723	2,369,763	34,974,974
2007	1,887,674	56,965,258	52,434,883	22,197,169	1,780,384	2,449,842	36,959,432
2008	1,887,674	43,786,374	38,909,295	16,114,455	1,209,990	1,911,739	36,537,338
2009	1,652,800	55,580,190	49,375,077	21,021,390	1,419,827	2,441,739	34,682,719
2010	1,674,800	58,037,633	51,572,177	22,108,308	1,508,734	2,626,119	35,047,933
2011	1,693,000	68,398,561	53,568,672	24,200,299	1,581,476	3,238,389	35,598,901
2012	1,702,100	71,574,675	56,809,978	24,113,242	1,649,410	3,713,536	34,847,247
2013	1,717,300	78,702,931	60,207,397	25,437,623	2,063,419	4,374,219	43,941,777
2014	1,732,500	81,971,322	63,270,432	24,303,466	2,928,302	6,310,323	46,956,723

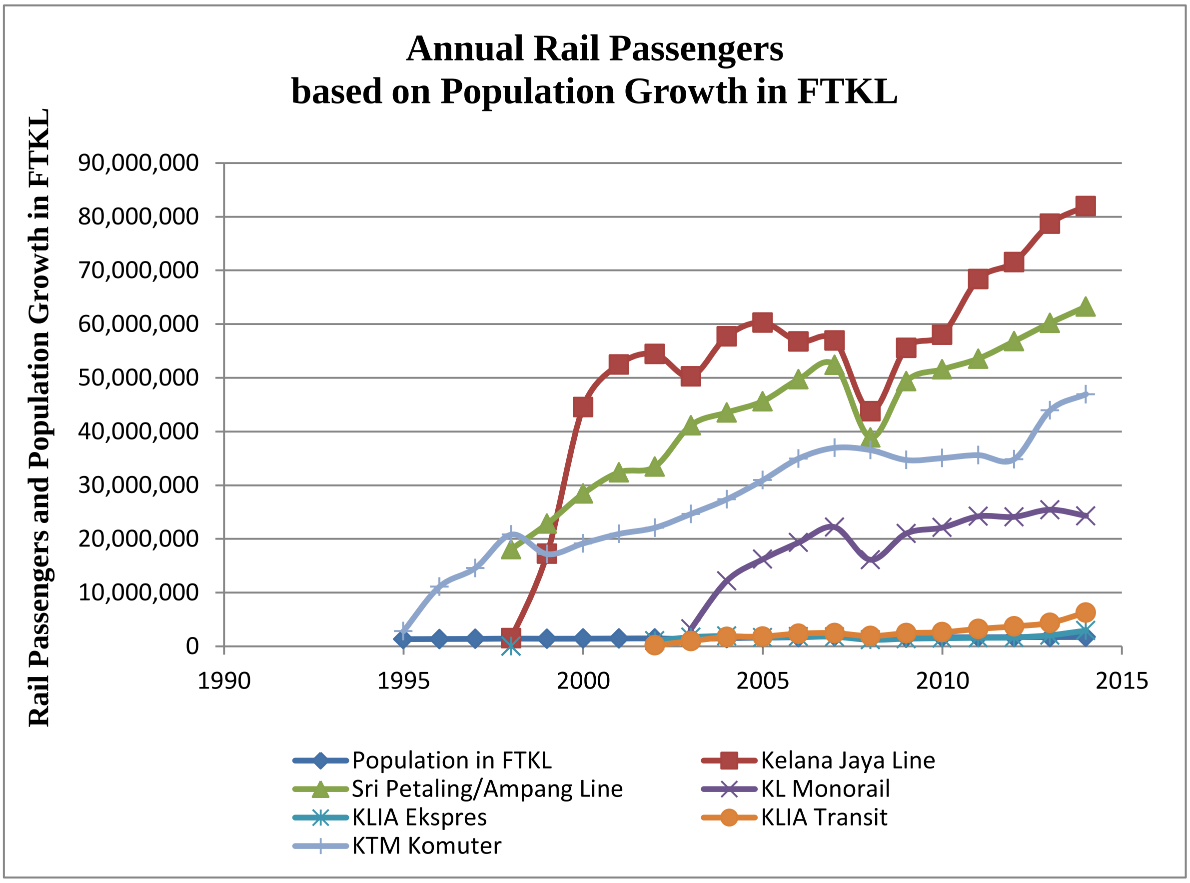

Figure 1.5 Annual Passengers of Urban Rail Transport based on Population Growth in FTKL

Sources: Economic Planning Unit of the Prime Minister Department (2006); Ministry of Transport, Malaysia (2009); Mustafa (2005); Jamilah and Amin (2007); Department of Statistics, Malaysia (1996); Ministry of Transport Malaysia (2009-2014)

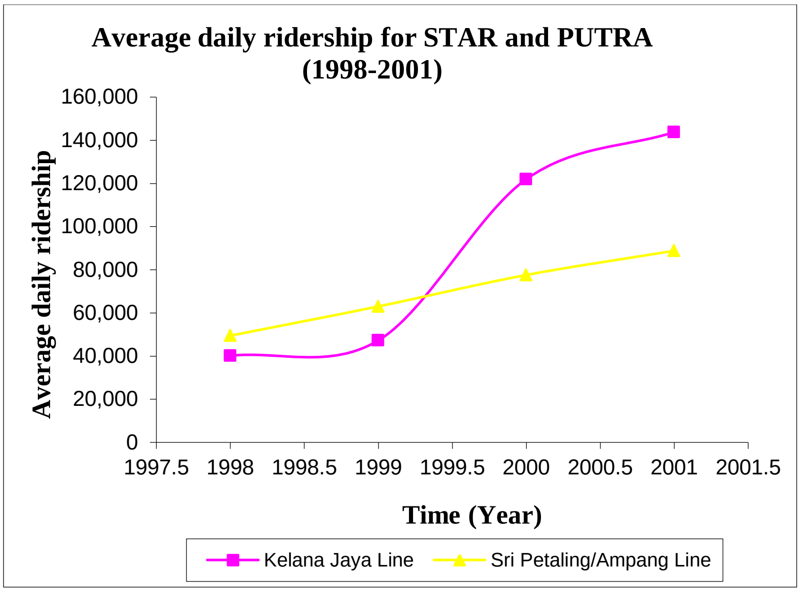

Figure 1.6 Low Ridership of STAR and PUTRA, 1998-2001

Source: Haji Zakaria (2002) as cited by Abdul-Rashid (2006)

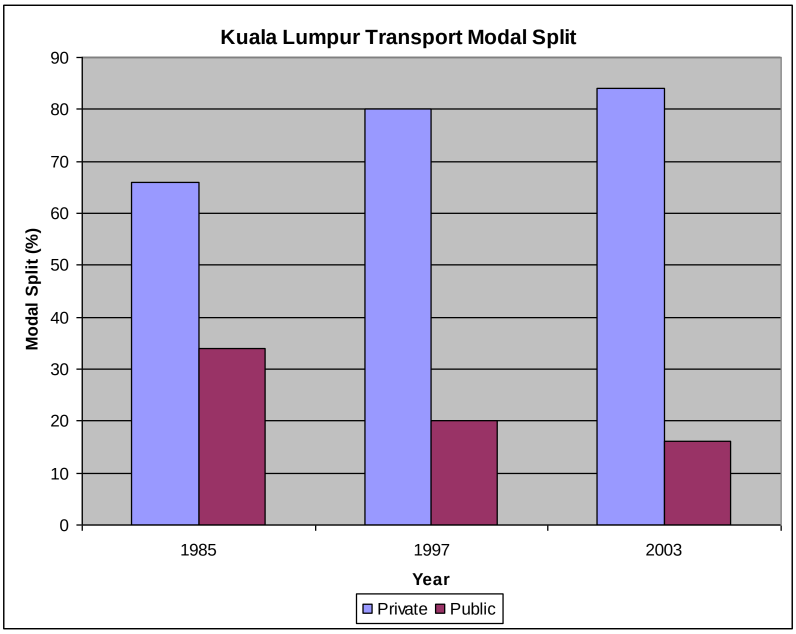

Figure 1.7 KL Transport Modal Split

Source: Hossain (2007)

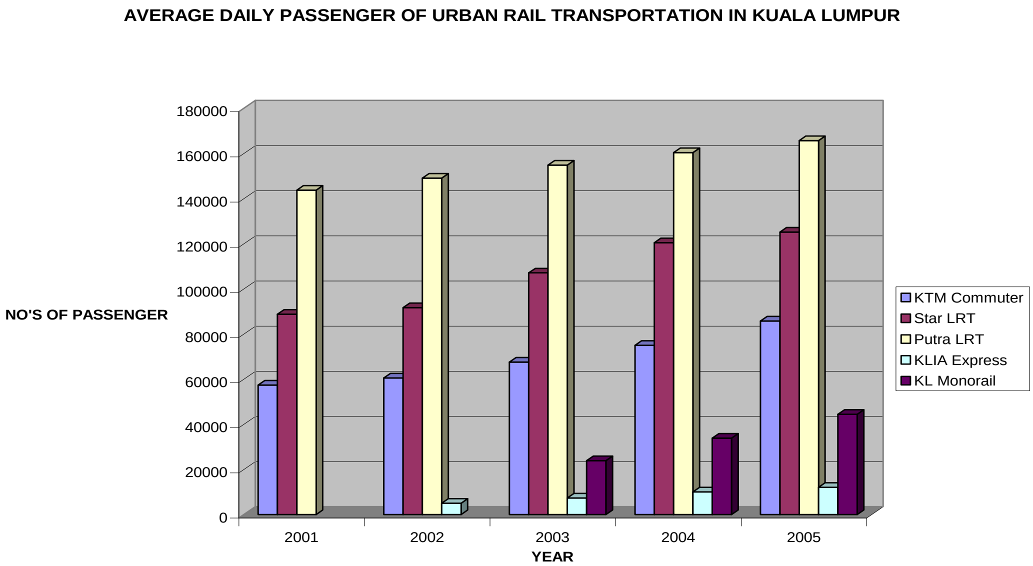

Figure 1.8 Daily Ridership on Rail Rapid Transit and Train Services in Kuala Lumpur

Source: Improving Infrastructure, Utilities and Urban Transportation. The Ninth Malaysia Plan 2006 – 2010, Chapter 18, pages 375 – 391, in Economic Planning Unit Malaysia (2006).

(e) There are inadequate feeder bus support services with respect to lack of frequency, service coverage and general access (inadequate parking and park-and-ride space). This had caused poor accessibility to rail services based on the GTP 1.0 Improving Urban Public Transport (Performance Management & Delivery Unit, 2011, accessed on July 9, 2014). Other negative drawbacks included longer waiting and in-vehicle times, queuing and overcrowding at bus stops and inside the buses, and at transfer points (Jansson, 1984, Shih et al., 1998). Feeder buses have been noted to provide better connectivity (Jain et al., 2014);

(f) There is poor level of security and safety; and

(g) Rail is often deemed as a promising mode of transport to reduce high dependency on cars. This is confirmed by (Performance Management & Delivery Unit, 2011, accessed on July 9, 2014) the fact that about 40% of daily public transport ridership is captured by rail usage. Owing to this, quality evaluation of rail services with respect to personal safety, travel time and transfer time are still a matters of concern in transport engineering (Eboli and Mazzulla, 2012; Syahriah et al., 2013; Chowdhury et al., 2014) at the national level (Jiang et al., 2012) in accordance with the GTP 2.0 Improving Urban Public Transport (Performance Management & Delivery Unit, 2011, accessed on July 9, 2014).

In view of the above-mentioned problem statements related to the research, the next subheadings will highlight the aims and objectives of the study.

1.3 AIM OF THE STUDY

The aim of this study is to determine optimal levels of *KTM Komuter* provision in terms of quantity and quality of service in an economical manner.

1.4 OBJECTIVES

The general objective of this study is to determine approaches to improve the quality of service of the mainline rail service in KL, Malaysia.

The specific objectives of this study include:

(i) To model the travel behaviour of *KTM Komuter* users and *KTM Komuter* trains based on the Origin-Destination survey results. Then, the study aims to demonstrate the practical values of the Generalised Journey Time (GJT) and Generalised Travel Cost (GTC) of the *KTM Komuter* operations also based on the O-D survey results;

(ii) To explore and identify the passengers' daily personal perceptions, experiences, needs and environment or situational influences of service quality attributes that best define a high quality rail service based on the factor analysis of the variables of service quality (on the basis of Attitudinal surveys);

(iii) To evaluate the service quality in the *KTM Komuter* systems by developing empirical, statistical models called KOMIQUAL models to determine which of these variables have an importance or the greatest impact on *KTM Komuter* quality and service for a network of routes/corridors;

(iv) To estimate the maximum number of *KTM Komuter* passengers per hour for seven time variations based on the Passenger Boarding-OnBoard-Alighting survey results and to gauge optimal headway, fleet size, TU or vehicle capacity and pricing based on the Stochastic Economic Optimization approach and then to establish the number of *KTM Komuter* train sets using the ROMAN-D software based on both the actual and design operating service frequencies in order to investigate their significant impacts on train service frequencies/schedules and space comfort by modelling a better *KTM Komuter* Timetable and Public Timetable; and

(v) To put forth policy recommendations to improve the quality of services of the *KTM Komuter* system.

1.5 HYPHOTHESES

Based on theories, empirical data, logic issues and some observations in reality, the assumptions to be tested include:

(i) The *KTM Komuter* service quality is sub-optimal in the aspect of generalised journey time and its total weighted travel times are considerably high; and

(ii) *KTM Komuter* service quality could be improved by utilising a combination of strategies to improve the quality (levels) of service (Nash, 1988, Nash, 2000, Bussieck, 1998, Litman, 2007-2015, Barra et al., 2007). This can be done by:

(a) increasing train efficiency in terms of service frequency to reduce generalised journey time, the total weighted travel times, generalised travel cost, waiting time, in-vehicle time, passenger and potential passenger queuing and overcrowding;

(b) decreasing a train's stop time at every rail station by improving boarding/alighting time and providing convenience with wider doors and/or a few doors in addition to increasing public transport vehicles, especially rail cars/coaches or set of trains, and ensuring that loading and waiting areas are comfortable. This is to solve issues concerning space comfort and/or passenger overcrowding on trains especially at doors during peak hours;

(c) improving soft services or skills pertaining to customer services and staff courtesy; and

(d) improving reliability or punctuality via better train schedules.

The above assumptions have induced the need to improve and optimize the existing rail public transport services from the passengers' perspective [user-optimization (Nagurney, 2007)]. Both passengers and revenue will increase if the operational and financial performance (or density and level of service, LOS) exploit best operating conditions at minimum average social cost (Nash, 1988; Bussieck *et al.* 2004; Abdul-Kader et al., 2010; Gallo et al., 2011), which will then directly impact changes to travel behaviour of rail users and potential users.

1.6 SCOPE

Based on the overview of the current scenario of public transport both in KL and the Klang Valley, and the previous literature related to quality of services worldwide, the present research, therefore, focuses on passengers' daily personal perceptions, experiences, needs and environment or situational influences of service quality attributes that best define *KTM Komuter* service that is of high quality.

This study examines the mainline rail service in KL i.e. the *KTM Komuter* services and particularly that which connects Sentul to Port Klang for the sample of urban to suburban rail operations in KL (refer to Figure 1.1). KL for the site location is defined as the Kuala Lumpur Core Urban Region (KLCUR). The approaches of this study will vary with regards to data collection methods, sampling location and procedures for certain field observations and measurements. Modelling and analysis will use the combined factor analysis and economic optimisation approach. Based on Table 8.5 and the KOMIQUAL (combined words consisting of KOMI i.e. the types of the commuter train models and QUAL referring to the word quality) models, the focus of the research is then on improving train service frequencies and schedules, soft services or skills and space comfort.

For reliable and sufficient findings, considerable efforts are devoted to data and information collection and management process. Equally, specific emphasis is placed on how data analysis and evaluation is to be carried out. Choice of data is governed by data availability. Travel behavioural and demographic parameters are studied. In order to investigate the significant impacts of the number of trains and train size (especially its length) on the operation of the entire rail route network, various ranges of flow rates, headways, density, transfer points and transfer waiting time are measured empirically at selected sites from Sentul to Port Klang. Jain et al. (2014) pointed out that the service quality and stress associated with transfers of the public transport have not been studied comprehensively. The subsequent step is to model such parameters as headway, vehicles and fares by optimising them.

The essential goal of this study is to compile as many necessary and relevant data and information as possible at sites to narrow down the gap between knowledge and experience toward a more realistic empirical model (Guihaire and Hao, 2008).

1.7 THESIS MOTIVATION AND INSPIRATION

This thesis is motivated by issues pertaining to private and public transport growth, usage and trips both in KL and the Klang Valley that has motivated and inspired the researcher to carry out this study. Specifically, it is the challenges to the quality of *KTM Komuter* services with respect to capacity, service frequency, accessibility, connectivity, mobility, on board crowding and station service quality that have resulted in the need to examine KTM Komuter's LOS and OSQ as perceived by its passengers.

The aim and objectives of the study were met after the researcher conducted comprehensive reading and reviewing on research background, literature especially the key journals, problem statements and the methodologies exploited. These aims and objectives were also formulated based on discussions conducted between the main supervisor and the researcher through a series of meetings and a-ninth month viva and an up-grade viva. The hypotheses and their results were based on a critical review on the methodologies, data and the findings of the study. These aims, objectives, hypothesis and the results of hypothesis were formulated and fine-tuned by the researcher through her working experience as a lecturer in highway and traffic engineering in UiTM Malaysia over the last fifteen years.

1.8 THESIS ORGANIZATION

The chapters of this thesis are structured as follows. In Chapter 2, public transport in Kuala Lumpur is reviewed covering subheadings that include introduction to the geographical core region of Kuala Lumpur, urbanization, economic development and industrialization, motorization, decline in public transport, road traffic congestion, accidents and environmental pollution, rail transport system as an alternative to car and bus usage, history of rail in Kuala Lumpur and rail operations in the Kuala Lumpur Core Urban Region. Chapter 3 defines key terms from the research topic and title under Section 3.1 whereas Section 3.2 briefly reviews prior work on service quality related to rail service industry. Chapter 4 reports the research methodology and analysis methods adopted for subsequent investigations. Chapter 4 looks into public transport demand models, attitudinal models and optimisation models. Combined Factor Analysis and Optimisation is also covered at the end of Chapter 4 to report on its application in successfully conducting stages of modelling and analysis. Chapter 5 describes the list of data requirements and availability. Origin-Destination survey results are provided in Chapter 6. Attitudinal survey results are compiled in Chapter 7.

Chapter 8 reports the results of attitudinal models. The final two chapters contain a discussion of the illustrative calculations that relate to Section 4.8, a discussion of the optimisation models for Port Klang – Sentul corridor, a derivation of a practical timetable from the optimised results for the seven time periods, some concluding remarks, and directions for future research.

1.9 CONCLUSIONS

The background of the research was considered as a conceptual framework and has led to the formulation of the problem statements of the research. The problem statements were then defined to formulate the aim, objectives and hypotheses of the research. More importantly, this introductory chapter has justified the need for the present work in the form of the scope under Section 1.6.

CHAPTER 2 : A SYSTEMATIC REVIEW OF THE LITERATURE

This chapter reviews the literature on services, service quality and service quality measurement. It provides a definition of the terms services, quality, optimal, quality of service (QOS), level of service (LOS), quality of rail service, public transport service, rail service and service quality. This chapter reviews various studies done on service quality, public transport services and service quality measurement. At the end of this chapter, a short appraisal of the importance of the previous work in relation to the researcher's own study has been included.

2.1 INTRODUCTION

Since the 1980s, there has been extensive research among researchers and professionals on the definition, modelling, measurement and management of service quality. This is because service quality has a strong impact on business (company) performance, cost, customer satisfaction, customer loyalty, customer retention, profitability and marketing. Companies gain more customers and more profits if high service quality which is much sought after is provided. The company will get more customers because high service quality will influence the customers' choice of shopping at supermarkets for instance. Service quality can be improved with technology for the purposes of marketing and networking between companies. Technology enables researchers and professionals to be aware of the details of conceptual models of service quality which in turn encourage continual service quality improvements with regard to LOS and overall service quality (efficiency), overall performance and profitability. Section 3.3 will systematically review the use of SERVQUAL by Parasuraman, Zeithaml and Berry (1985) and its modification in service quality research.

2.2 DEFINITION OF KEY TERMS FROM THE RESEARCH TOPIC AND TITLE

Service involves a particular train running from point A to point B (for example, the service from Port Klang to Sentul). Macário (2010) mentioned that services are often consumed by customers. Public transport service is a transportation service offered by a public transport operating agency to the public. It is classified by type of operation (e.g. *KTM Komuter*, express and intercity services), time of operation and types of routes and trips served (Vuchic, 2007). Therefore, Ceder (2007) defines rail service as a combination of vehicle type, network and service attributes. The associated service attributes range from service frequency, acceptable travel time, service schedule, acceptable on-time performance, acceptable seat availability, reasonable waiting time, good information system, attractive interior vehicle design (chairs, air-conditioning) and on-board special features (TV, coffee, newspapers, etc.).

With reference to the Cambridge University Press (2005), quality in general refers to standard or how good or bad something is. The operationalization of quality concepts is the level of service (the production perspective) and quality of service (the consumption perspective) (Macário, 2010). LOS and QOS are two broad terms used to evaluate transportation services. According to Tukis and

Nizamuddin (2012), service is regarded as quality if it achieves the expectation and needs of the customers.

A common meaning for QOS refers to a user's perception on an acceptable operation of a transportation service or facility. Transportation Research Board (2013) defines QOS as the overall measured or perceived performance of transit service from the point of view of passenger. Muhamad Nazri et al. (2014) stated QOS as a measure of how well the level of service offered matches passengers' expectations. Quality of rail service means the level of enjoyment, comfort and health in rail service. Early definition of service quality is reviewed through the literature by Cunningham et al. (2000) and that they recognized perceived service quality as one of attitudinal factors while it is treated as satisfaction when being tested empirically. Alternatively, Ceder (2007) technically defines quality of rail service as forms depicting some qualitative elements of the whole levels of rail service affecting preferences of passengers such as riding comfort and convenience, high reliability, perceived personal security and safety, perceived overall 'image' of each mode, travel time, cleanliness and aesthetics. In most cases, increasing the QOS, for example, with regards to service coverage, service frequency and fare reduction impacts public transport demand positively (Ceder, 2007). Similarly, Vuchic (2007) defines service quality as qualitative elements of service, such as convenience and simplicity of using the system, riding comfort, aesthetics, cleanliness and behaviour of passengers. Vuchic (2005) defines service quality as all elements needed for scheduling of operations. Beirão and Sarsfield Cabral (2007) comment that 'service quality is perceived as an important determinant of users' travel demand.' This was supported by a sincere comment from a car user under study i.e. service quality meant driver moves from point A and being able to get to point B comfortably and fast, and by doing so satisfying his (in this regard, 'his' is a car owner and an occasional public transport user) needs. While Cunningham et al. (2000) and Chou et al. (2011) point out quality of service is an indicator most frequently used to measure the success of a marketing strategy. To be more concise, the term service quality is generally understood to mean a customer's evaluation of LOS, particularly Lai and Chen (2011) specify such LOS as the service attributes consisting of the common features of the public transport system and infrastructure like terminals, stations, vehicles, and transport points (transfers) as highlighted by Cunningham et al. (2000), Zainudin (2012) and Chowdhury et al. (2014). In their research, Lai and Chen (2011) alternatively define service quality as the mass rapid transit passenger's assessment of the standard of the service delivered.

Users compare LOS provided by different transport operators by evaluating it in the form of quality and in turn decide which transport mode for a specific journey. So, LOS is quantitatively classified by QOS (Macário, 2010). LOS comprises factors, such as speed, reliability, comfort and so forth that affect passengers and that which basically influence the public transport's potential to attract passengers (Vuchic, 2005). These factors are a set of travel components. Such factors can be grouped into three: performance elements, service quality and price (Vuchic, 2007). Performance elements consist of operating speed, reliability and safety. Service quality is mentioned in the previous paragraph. Price denotes public transport service rate or fare i.e., the amount a user must pay for services used. Slightly improved LOS or service quality can significantly increase public transport attractiveness and travel (Keuchel and Richter, 2011) while poor service or public transport fares (costs) hike may decrease passenger volume and public transport attractiveness (Vuchic, 2005; Keuchel and Richter, 2011). While Brons et al. (2009) define LOS as rail service and the access to it, Hensher et al. (2011) consider components of LOS in relation to time, frequency, number of transfers, crowding and getting a seat for public transport as part of their new stated modal choice experiment conducted in 2009 for Sydney.

Optimal is also optimum meaning the best or most favourable; most likely to bring success or advantage (Cambridge University Press, 2005 and the (Oxford University Press, 1999). According to a website, http://www.investorwords.com accessed on 2nd January 2013, optimum is defined as 'the most preferred choice by consumers subject to budget constraints, a profit maximizing choice by firms or industry subject to technological constraints, or in general an equilibrium, where there exists a complete allocation of factors and goods that in some sense can maximize welfare'.

2.3 SCIENTIFIC LITERATURE IN SERVICE QUALITY, PUBLIC TRANSPORT SERVICES AND SERVICE QUALITY MEASUREMENT

This chapter will elaborate in depth the concept of quality and rail service to ensure greater satisfaction in the utilization of services among *KTM Komuter* users. There is a significant quantity of published literature that reports on the quality of rail passenger service. However, some of them adopt the Structural Equation Modelling (SEM) methodology and it is in this chapter that the criteria of quality and efficient rail services are explored.

Increased efficiency of rail service leads to increased satisfaction among passengers using this mode of transport (Mohd Yusof, 2002, Chou and Kim, 2009). A service is referred to as 'a human activity employed in order to benefit someone', and 'it ensures fitness for use, zero defects and variability reduction' (Juran (1964) as cited by Calabrese (2011)). In their study, Wardman et al. (2001) reported that instrumental, psychological and cost benefits clearly defined service performance. These benefits also determine the efficacy of the service delivery for both bus and train samples. In addition to that, instrumental travel needs were measured by reliability, frequency and speed; specific criteria for psychological travel needs ranged from safety, ease and simplicity, comfort and cleanliness and cost benefits like fares being of good value and affordable to passengers. Therefore, service quality is related to a description of a series of public transport attributes (Oña et al., 2012). 'Customers hence become the sole judges of service quality' (Filippi et al., 2013) or in other words 'service quality should be measured from the customer's perspective' (Berry, Zeithaml and Parasuraman (1990) as cited by Nuraiza (2000), Oña et al. (2012)) and (Irfan et al., 2012). More specifically, 'service quality can be measured by gauging the passengers' perception towards the operator's attributes that describe the service' (Oña et al., 2012, Chou and Kim, 2009). Service providers should understand and look forward to the rights and needs of the customers (Tukis and Nizamuddin, 2012). On the other hand, service quality can be measured from the customer's expectation and satisfaction of the organization's capability (Lai and Chen, 2011; Irfan et al., 2012; Rohana et al., 2012).

Some of the earliest studies in public transport industries were undertaken by Allen and DiCesare (1976) and Silcock (1981a). Performance measures were classified into quantity of service, quality of service and cost/revenue (Allen and DiCesare (1976) as cited by Cavana et al. (2007)). Allen and DiCesare (1976) further classified quality of service into two categories: that of user and non-user. The user category looks into satisfaction towards speed, reliability, comfort, convenience, safety, special services and innovations. The non-user category, however, delves into system efficiency, pollution and demand. The components of service quality include physical quality, corporate quality and interactive quality according to (Cavana et al., 2007). ‘Physical quality is the physical aspects of the service; corporate quality is concerned with the image of the organization whilst interactive quality applies to interaction among people’ (Lehtinen and Lehtinen (1982) as cited by Cavana et al. (2007)). The definition of service quality is that of ‘global judgment or specific attitude relating to the superiority or excellence of service’ (Parasuraman et al., 1988). Parasuraman et al. (1988) developed the SERVQUAL instrument (as cited by Cavana et al. (2007)) that was widely used in service businesses in accordance with Cunningham et al. (2000) and Chou et al. (2011). Silcock (1981) and Pullen (1993) took into account service quality concept as measures of accessibility, reliability, comfort, convenience and safety. Theoretically and conventionally, efficiency and effectiveness are performance indicators for public transport. Efficiency is used to determine the process that produces the services (Prasad and Shekhar, 2010b, Karlaftis and Tsamboulas, 2012). Practically, efficiency is often described by service frequency, schedules and reliability/punctuality. Pullen (1993) conceptualized quality of service under the effectiveness category. Under this category, the measures are concerned with how well services are provided in respect to the objectives that are set for them (Prasad and Shekhar, 2010b, Cavana et al., 2007). ‘It is composed of accessibility, reliability, comfort, convenience and safety' (Cavana et al., 2007). Pullen (1993) introduced level of transport service (LOTS) to measure the quality of service based systematically on travel speed and comfort. He proposed a set of uniform national standards of service similar lines to the LOTS concept. The LOTS concept refers to a system for evaluating features of public transport used to reflect quality of service. Pullen (1993) suggested that daily and new public transport systems be managed and improved systematically.

Steer Davies and Gleave (2000) as cited by Rahaman and Rahaman (2009) conducted a study on railway passenger service quality valuation in relation to the importance of rail passengers in improving the range and quality of facilities and service at stations and in trains. Steer Davies and Gleave (2000) as cited by Rahaman and Rahaman (2009) also provided 'guides on monetary valuation of the improvement of service for a number of passenger groups'. In the railway passenger service quality valuation process, about 22 attributes are exploited to identify significant attributes.

Agarwal (2008) reviewed many service quality literature in relation to public transport but none of them described the service quality in the Malaysian context. In Agarwal's (2008) study, it was found that employee behaviour was the most significant factor to impact the overall satisfaction/dissatisfaction levels of passengers towards the Indian Railway services. In specific, it was the "empathy" exhibited by the employees' behaviour which had an impact on the overall satisfaction/dissatisfaction levels of the passengers. Agarwal (2008) noted "that an organisation needs to understand the requirements and expectations of customers to manage an effective relationship with customers" (Annamalah et al., 2011, Chou and

Kim, 2009). For this reason, the organisations have to look into factors that defined customers' satisfaction and dissatisfaction levels. The standardized beta coefficients in the results also highlight factors such as customer-oriented basic platform services, reservation counters, services on train, tangible platform amenities and availability of trains and tickets affecting the overall satisfaction levels of the customers from the greatest to the least.

Parasuraman et al. (1991) as cited by Low (1994) refined SERVQUAL and replicated it into five different customer samples: a telephone company, two insurance companies and two banks. However, Parasuraman et al. (1991) as cited by Low (1994) modified the SERVQUAL scale in two ways: 'in a change of orientation from the LOS that should be provided to the level that would be provided, and the transformation of all negatively worded items into positively worded statements'. They confirmed the usefulness of the SERVQUAL scale. Cronin and Taylor (1992) as cited by Low (1994) and Lai and Chen (2011) concluded that the SERVQUAL was flawed as it was based on a satisfaction paradigm rather than an attitude model, so it was unsuitable in certain service businesses. They came up instead with empirical and literature information that service quality should be measured as an attitude. Therefore, they developed a performance-based scale called SERVPERF. The SERVPERF explains the variation in service quality in more detail than SERVQUAL. Cronin and Taylor (1992) as cited by Low (1994) and Lai and Chen (2011); and Chou and Kim (2009) confirmed that perceived service quality led to satisfaction as proposed by Parasuraman, Zeithaml, and Berry (1988). Finally, satisfaction appeared to have a stronger effect on purchase intentions than service quality.

There have been three applications of the SERVQUAL scale in South East Asia, one in Malaysia and two in Singapore. The Malaysian study on service quality, a consumer perception of the banking sector was carried out by Lim (1992). Her study extracted four dimensions of service quality in the commercial banks instead of the five dimensions by Parasuraman et al. (1988). The four factors were technical service, personal attention and responsiveness, security, and appearance and courtesy. Technical service factor was made of the tangibles and reliability dimensions in the latter's study i.e. Parasuraman et al. (1988) study. Personal attention and responsiveness was a combination of the responsiveness and empathy dimensions. While the security factor was formed by the assurance dimension, appearance and courtesy which were the original new factors in the study. Kaura (1993), Ow (1994), Grotenhuis et al. (2007), Too and Earl (2010), and Irfan et al. (2012) in their studies on service quality measurement differed from Lim's (1992) study in that they had measured the 'SERVQUAL score, which was defined as perception minus expectation score'. They assessed the overall service quality as perceived by the respondents. They further measured the SERVQUAL score for the five dimensions, the average value and the weighted average.

Chapter 3 of the Handbook for Measuring Customer Satisfaction and Service Quality, TCRP Report 47 (Transportation Research Board, 1999) defines ten key categories labelled as 'service quality determinants' which are reliability, responsiveness, competence, access, courtesy, communication, credibility, security, understanding/knowing the customer and tangibles. Tangible includes the physical environment and representations of the service. These ten dimensions and their descriptions were first found in the basic service quality model proposed by

Parasuraman et al. (1985) in an exploratory analysis of academicians of marketing (Too and Earl, 2010). To further formulate a service quality framework, Parasuraman et al. (1988) discussed in detail the conceptualization of service quality. They also developed a model comprising generic dimensions such as reliability, assurance, tangibility, empathy and responsiveness (Lai and Chen, 2011) or RATER (Geetika and Nandan, 2010) for another framework to measure the service quality in public transportation.

The five dimensions and their concise definitions are as follows:

Tangibles:	Physical facilities, equipment, and appearance of personnel.
Reliability:	Ability to perform the promised service dependably and accurately.
Responsiveness:	Willingness to help customers and provide prompt service.
Assurance:	Knowledge and courtesy of employees and their ability to inspire trust and confidence.
Empathy:	Caring, individualised attention the firm provides its customer.

So, the earlier ten dimensions were reduced to only five dimensions or factors. These generic dimensions are affected very much by population specific characteristics like demographics and public transportation specific determinants. Hence, the construct of service quality measurement needs to be modified to match the present study context with the extension of generic SERVQUAL dimensions consisting of additional dimensions representing the context of the study (Randheer et al., 2011). For example, previous research by Paul and Alan (1996), Malhotra, Agarwal and Peterson (1996), Malhotra et al. (1994); Malhotra et al. (2005); Mattila (1999); Winsted (1997); Liu and McClure (2001); Karen and Boo (2007) and Satyabhusan et al. (2009) identified culture to be an important new dimension in measuring service quality. Culture guides the lifestyle and influences behaviour. Culture has a significant effect on consumer behaviour with regards to service consumption. A research has explored the cultural differences in consumer behaviour. Hofstede (1991) as cited by Randheer et al. (2011) studied about national cultures in line with competence, communication, credibility and courtesy. He also considered cultural dimensions as power distance among organizations and presence of individualism or collectivism in the society. Prasad and Shekhar (2010c) modified the attributes in the SERVQUAL model and created the RAILQUAL model to measure the perceived service quality of rail transport users. They identified reliability, tangibles and assurance as the most significant predictors of overall service quality. These findings were similar to those of Parasuraman et al. (1988) except that the remaining variables namely, responsiveness and empathy were not statistically significant at the 5% level. However, "the literature review clearly indicates that different variables would be important for different services for customer satisfaction" (Geetika and Nandan, 2010). In other words, the determinants of service quality vary with services but the literature focuses on the possible determinants of service quality. For example, the selection of variables to measure customer satisfaction levels were based on three broad categories namely ticketing, on-board services and facilities at railway platforms of the Indian Railways. These variables were further broken down to 16 variables in order to formulate a questionnaire (Geetika and Nandan, 2010).

Another similar study was carried out to identify relationships between service quality and user perception in terms of tangibility, reliability and responsiveness of public transports but more so towards buses and taxis in the Lembah Bujang area in Kedah (Zaherawati et al., 2010). The important railqual factors identified by the passengers used to evaluate the service quality of Indian railways were reliability, assurance, empathy, tangibles and responsiveness (Vanniarajan and Stephen, 2008). Alternatively, Vanniarajan and Stephen (2008) identified that reliability, assurance, empathy, tangibles and responsiveness affect customers' satisfaction levels towards railway services (Annamalah et al., 2011). This was the same as the 22 quantitative item scale, called 'SERVQUAL' (Cunningham et al., 2000; Too and Earl, 2010; Lai and Chen, 2011) and 25 RAILQUAL variables were generated to analyse the service quality dimensions in the Indian Railways.

There are lists of quality determinants to understand service quality. These significant and quality determinants will help develop a required model. The best known model originated from Parasuraman et al. (1985) and this is, the SERVQUAL (Tohidi and Jabbari, 2011). However, there are very limited published journal findings on the exploitation of SERVQUAL in the rail industry. Prasad and Shekhar (2010b) evaluated the passenger rail service quality of the Indian Railways by developing the Service Quality Management (SQM) model. The SQM model was a new model, modifying both the SERVQUAL model and rail transport quality. The model modified rail transport quality by grouping the attributes of the rail transport quality together to form possible items for measurement of railway passenger services. The original attributes in the SERVQUAL model i.e., reliability, assurance, tangibility, empathy and responsiveness were modified with the addition of three new dimensions namely, service product, social responsibility and service delivery for the development of the SQM model. This is because service quality should be measured on a multidimensional facet with the gap model of service quality and concept of transport service quality being the major bases. Service quality gap model relates to the customers' perceived gaps and service quality gap is the gap between services that customers expect and what they have felt (Cheng and Yan, 2008). Concept of transport service quality refers to the attributes in the public transport industry and the railway service sector. For example, the attributes in the SERVQUAL model, the public transport industry and the railway service sector should be grouped together to form possible items or variables for measurement in order to measure the quality of services thoroughly. This is because each model has different characteristics. The SERVQUAL model is a customer-related model whereas measures of public transport industry are much more mechanistic or technical (Prasad and Shekhar, 2010b). Consequently, the research would examine the service quality measurement in various services of the Indian Railways to monitor, control and improve its service and to increase competitiveness. The model was tested for reliability and validity. An empirical study was conducted with the survey taking the form of randomly selected respondents at the Secunderabad Railway Station of South Central Railway, India. Valid responses from the questionnaires were statistically analyzed using the factor analysis. Interestingly, this research highlights that the most important factor is service delivery whilst the least important factor is social responsibility on the basis of inferential statistic evidence (factor analysis resulted in eight factors).

'In 1985, Parasuraman, Zeithamall and Berry introduced the model of service quality gap. This could be utilised as service organizations to enhance the quality of service and the marketing's basic framework' (Cheng and Yan, 2008). The model of service quality gap can assist managers to identify service quality related problems (Tohidi and Jabbari, 2011). In Cheng and Yan's (2008) research, the model of service quality gap was used to analyze the five kinds of gaps of urban rail transit service quality, which were consumer expectation-management perception gap of operating enterprise, management perception-service quality specification gap, service quality specifications-service delivery gap, service delivery-external communication gap and service quality gap; and to identify the operating enterprise's quality standards and external publicity. Thus, the analysis of the service quality could gauge the management of urban rail transit services intensely. Significant service management attributes of urban rail transit means the overall service management process of guaranteeing and improving the quality of services to meet the basic needs of rail passengers.

The general SERVQUAL models were tested and applied in various service quality research such as hospital, healthcare, bank, internet banking, informational systems, airline services, hotel, food and beverage outlets, consultancy services, library and public services (such as gas and electricity), internet service providers (isp), telecommunication, electronic business, university, retail chains, the tourism industry and transportation (Cavana et al., 2007, Annamalah et al., 2011, Tohidi and Jabbari, 2011, Kim, 2011, Calabrese, 2011, Too and Earl, 2010) in countries such as the United States, the Netherlands, UK, Australia, South Africa, Cyprus, Hong Kong, China and Korea (Irfan et al., 2012). ‘The SERVQUAL framework from the marketing literature was brought into the transport sector for service quality research referring to weaknesses in service quality and satisfaction levels and were used interchangeably in much of the transport literature’ (Cavana et al., 2007). The original attributes in the SERVQUAL model i.e., reliability, assurance, tangibility, empathy and responsiveness were modified empirically with the addition of three new dimensions namely, convenience, comfort and connection and were also modified after the Exploratory Factor Analysis (EFA) for the development of the extension to the three-column format SERVQUAL model (Parasuraman et al., 1994). This was done for a passenger line in the rail passenger sector, Rail Co. in Wellington, New Zealand to measure passenger rail service quality (Cavana et al., 2007). In short, the service attributes used in this research were derived from a thorough literature review and the EFA. The EFA was conducted due to the complex nature of rail passenger service which involves several services (areas) and attributes during service delivery. A distinctive feature of the extended three-column SERVQUAL instrument is its diagnostic characteristic with respect to zones of tolerance and expectation management. It guides management in terms of rating the effectiveness of service quality and looks into problem areas (services) which need to be improved (Cavana et al., 2007).

In the conceptual framework for measuring rail passenger service quality that was an expansion of the three-column model, the expected service was divided to that of desired level and adequate level. Managers will develop long-term and short-term strategy planning with the help of the perceived service quality rating relative to the expected service to improve problem areas. Zones of tolerance are regions that separate the desired service level and the adequate (minimum acceptability) service level. The zones of tolerance provide information on the services (areas) and attributes that need to be improved on. Since the newly expanded three-column format SERVQUAL model contains eight factors for measuring perceived service quality, thus all these eight factors are entered in the multiple regression equation to predict the overall service quality. This multiple regression method identifies three significant factors namely, assurance, responsiveness and empathy that have significant effects on the overall service quality whereas the direct method identifies reliability and convenience as very important factors of quality. With reference to the TCRP Report 47 (Transportation Research Board, 1999), responsiveness is more on employees' willingness or readiness to provide service and it also involves service timeliness. Assurance concerns the behaviour of employees in Public Transport Services and instils confidence in a regular commuter using Public Transport Services. It also means employees in Public Transport Services area being consistently courteous with passengers and having the knowledge to address questions forwarded. Empathy means the Public Transport Services giving attention to women, children and the handicapped. It also means that the Public Transport Services have operating hours convenient to all its customers. It also refers to the Public Transport Services employees giving passengers personal attention (Randheer et al., 2011). 'The passengers, however, on the whole deemed all these factors as relatively pertinent' (Cavana et al., 2007).

There is a local research on measurement of rail service quality using the SERVQUAL scale. SERVQUAL scale means the application of five basic dimensions of service quality, namely RATER as mentioned in a previous paragraph. According to Lai and Chen (2011), SERVQUAL provides a means of measurement for researchers to determine how well the LOS is delivered and how it matches a customer's expectations on a consistent basis. This study was done by Low (1994). The aim of her research was to focus on customer problems to improve rail service quality. Her main focus was to apply the SERVQUAL instrument developed by Parasuraman et al. (1988) to measure the perceived service quality of rail transport users in a local organisation of the services industry, that was, the *KTMB*. Various dimensions were extracted from the 22-items SERVQUAL instrument using the factor analysis as discussed. Earlier her study was confined to measuring the unweighted and weighted SERVQUAL scores, determining the dimensions of service quality and identifying the importance of the dimensions. She also examined the influence of demographic variables on the SERVQUAL scores. She had 133 employees from various government departments as her study respondents. The most important predictors of service quality were found to be reliability, tangibles and assurance. The other two dimensions were identified as inadequately explained by the items extracted. Age, occupation, income level and educational level had significant influences on the SERVQUAL scores. She concluded that *KTMB* users were moderately satisfied with the quality of services provided.

Hanna and Drea (1998) explored the quality of Amtrak services. Amtrak provides scheduled intercity passenger rail services in the United States. It is a national rail system. A study on the attributes of quality of service that influences the decision to use Amtrak as a travel option compared to the automobile was explored by Hanna and Drea (1998). Their research found five factors that influence choice of transport. The five factors were identified by a series of six focus groups conducted with business travellers, leisure travellers and student travellers in three regions of Illinois. However, a detailed literature review produced the viable attributes. The five factors were cost, comfort, ability to travel when 'I' want to (timing), ability to travel where 'I' want to (location) and in-transit productivity (ability to work while travelling) (Hanna and Drea, 1998, Cavana et al., 2007). Of these factors, four of them namely, cost, comfort, ability to travel when 'I' want to (timing) and ability to travel where 'I' want to (location) were found to be of great importance to all travellers whereas in-transit productivity was specially preferred by business travellers. Other results based on a further examination of the model showed that in-transit productivity was greatly important to Amtrak riders while the ability to travel where 'I' want to (location) was of most important to non-Amtrak riders. The binomial logit model was chosen to determine which independent variables would help explain differences in an individual passenger's ridership decision and to formulate strategic planning for improvement. The tested independent variables were convenient departure and return times, convenience from the station to the destination, customer not having Amtrak schedule information, the importance of in-transit productivity, the importance of can travel where 'I' want to (location) and the importance of can travel when 'I' want to (timing). From the statistical analysis, four variables namely, convenience from the station to the destination, customer not having Amtrak schedule information, the importance of in-transit productivity and the importance of can travel where 'I' want to (location) had significant impacts on the travel decision to ride Amtrak. The other two variables were convenient departure and return times and the importance of can travel when

'I' want to (timing) at [p=0.0544] and [p=0.0539] respectively. Amtrak management should consider these factors impact as elements that influence ridership decisions. Hanna and Drea (1998) concluded that 'customers perceive the actual on-board experience provided by Amtrak as being adequate.'

Drea and Hanna (2000) also investigated the quality of Amtrak services. Similar to Hanna and Drea (1998), they too studied the attributes of quality of service that influenced the decision to use Amtrak as a travel option compared to automobiles. Their research found eight factors that influenced choice of transport. The eight factors or quality attributes were cost, convenience getting to the boarding station, parking availability, Amtrak comfort, seat comfort (on the train), the ride, seating area cleanliness and courtesy of on-board staff on the train (Cavana et al., 2007). These eight factors were chosen through focus groups conducted with each group of riders prior to the survey development process. 'Convenience of getting to the boarding station and parking availability were relevant measures of overall passenger perceptions about the convenience of Amtrak' (Drea and Hanna, 2000). The statistical analysis of the five on-board environment measures involved the principal axis factor analysis, allowing the application of factor. The principal axis factoring is a type of extraction method in factor analysis and the principal axis factor analysis using SPSS is significantly pertinent to reduce data (Field, 2005). Drea and Hanna (2000) concluded that "train riders' attitudes towards train travel became more positive and behavioural intentions increased when competitive travel alternatives were weak" (Tripp and Drea, 2002). Niche strategies are represented by maximize riders and revenues. Effective niche strategies are necessary for the long-term success of Amtrak.

Tripp and Drea (2002) also conducted a three-week survey on train passengers on-board Amtrak. The purpose of this survey was to empirically assess 'the direct and indirect relationship between pre-core and core service performance components and their impact on the likelihood of repeat purchase' (Cavana et al., 2007). From 19 service encounter elements measured among the Amtrak riders, these elements were effectively reduced to peripheral components (pre-core or peripheral) and core components by using the principal components factor analysis. The peripheral service factors were divided into antecedents to ridership and boarding station conditions. Antecedents to ridership were measured by assessing ease of obtaining a ticket, convenience in getting to the station, parking availability and parking security whereas boarding station conditions included comfort, cleanliness and safety. Meanwhile, core service factors included on-board conditions, café car conditions and on-time performance. At the end of Tripp and Drea's (2002) research, the core service encounter elements on-board were found to be significant determinants of affective response towards the service provider and behavioural intentions to ride again. These on-board conditions consisted of announcements, seat comfort, ease of ride, cleanliness of seating areas, courtesy of on-board staff and perception towards rest rooms. The exogenous variables of a full model of the effects of service elements on attitude toward the service provider and repeat purchase intentions were in the form of antecedents to ridership, boarding station elements, on-board elements, café car elements and on-time performance. An alternative model was then established by the core elements of the service viz. on-board elements, café car elements and perceived on-time performance. A structural path modelling procedure in Amos, a computer programme to help in a SEM modelled the effects of service conditions was used. The concluding remarks regarding the overall results implied that on-board service encounters were the most important service attribute for retaining riders and boosting ridership. It can also be concluded that 'the impact of core and pre-core service elements on attitudes and behavioural intentions suggested a need to understand the disaggregation of service performances better' (Tripp and Drea, 2002).

Past research has proven that assurance and reliability have great impact on satisfaction levels and loyalty. For example, the Transportation Research Board (2009) found that reliability and assurance were the main factors which affect customer's satisfaction in railway services.

Ugurlu et al. (2011) investigated the quality of the Istanbul Metro services. They studied the attributes of quality of service that influenced the decision to use Istanbul Metro and its users' satisfaction levels. Data collected from a customer satisfaction survey were processed to conduct traveller satisfaction ratings and this was followed by an Exploratory Factor Analysis (EFA). This was essential to determine the main dimensions from a high number of satisfaction level-based questions. At the end of the EFA, there were ten most important satisfaction level-based questions looked into consistency to the declared time plans, travel time, waiting time, access to station, safety and security levels at the station, safety and security levels in vehicles, the manner and attitudes of security personnel, cleanliness of vehicles, the air condition system in the vehicles and the level of crowdedness in the vehicles. Through EFA (sixty three percent of the variance was explained), the service quality attributes which determine satisfaction towards Istanbul Metro service were extracted. These final service quality attributes represented the passengers' perceptions of service performance. They ranged from accessibility, comfort, safety, security, to time. These final service quality attributes were exploited to describe 'the relationship between the LOS delivered to the passengers and the passengers' expectations of the services provided' (Ugurlu et al., 2011).

Lai and Wu (2011) investigated the quality of the Kaohsiung Rapid Transit System (KRTS) services in Taiwan. They studied the attributes of quality of service that influenced the decision to use KRTS which provided passenger-oriented services. The general SERVQUAL models were modified using the service quality features of the rapid transit system presented in Su's (2001, 2008) research to obtain the final 27 service quality features of KRTS. Results from the factor analysis showed that there were six factors extracted and that 20 items were retained. The six factors extracted were assigned under the following labels: empathy, reliability, responsiveness, convenience, tangibles and assurance. After performing the factor analysis, the approach of Kano's model resulted in the Kano's classification of 20 KRTS service quality items. This format would make room for the analysis of the independent sample t-test and one-way ANOVA. Possible findings of the independent sample t-test and one-way ANOVA, 'revealed that gender and purpose of utilising KRTS were the two main variables that had the most items of significant mean difference among the total 20 service quality items of KRTS services' (Lai and Wu, 2011). It can be concluded that the above techniques helped to first measure and evaluate passengers' service quality requirements of KRTS services and then identify significant demographic variables for market segmentation which could lead to different marketing strategies.

Chapter 4 (Transportation Research Board, 1999) proposes the bivariate (pearson) correlation, the multiple regression analysis, factor analysis and combining factor analysis and multiple regression analysis to statistically determine the importance of an attribute on the relationship between individual ratings (predictors) and the overall satisfaction rating. This chapter (Transportation Research Board, 1999) further proves that at present, factor analysis combined with multiple regression analysis has been the most popular statistical technique used in data analysis of customer satisfaction and service quality in research within the transit industry. Several research have proven the use of these analytical techniques and Cavana et al. (2007) mentioned that these techniques are not complex in data analysis. This explains the choice of combining factor analysis and the use of SEM method in the current research.

Wahida's (1997) research oversaw the existing problem in the public transport sector and the planning of transportation in KL. The objective of the research was to evaluate the LOS provided by *KTM Komuter*. The quality of service measured was fare, comfort and frequency of trips. Primary data was collected through an interview and survey. *KTMB* staff, officials from KL City Hall and Urban Transport Department, and *KTM Komuter* passengers were interviewed. The survey focused on the perception of respondents on the quality of service provided by *KTM Komuter*. The main hypothesis was to prove that there was a relationship between ownership of vehicle and users of *KTM Komuter* service. It highlighted that there was a weak positive relationship with the usage of the Yule's Q Analysis. The usage of *KTM Komuter* did not depend on vehicle ownership. Variables such as level of income, distance between home and the workplace, mode of transport to the station, purpose of journey, waiting time and journey time influenced the usage of *KTM Komuter* service. Most of the passengers were satisfied with the current LOS provided by *KTM Komuter*. The planning and future developments of KL transport system were greatly influenced by the process of urbanization, population, income, employment and land use (Wahida, 1997).

A similar study was executed on a current research to analyze customers' perception towards *KTM Komuter* services in Malaysia. This was done by Fazlina et al. (2010). Data from twelve *KTM Komuter* stations were used to measure services via aspects pertaining to punctuality, frequency, speed, space, reliability, comfort, safety and train operations. The logistic regression analysis was used to identify the factors that could influence the efficient services provided by *KTM Komuter*. Results revealed that the factors that influenced efficient services most were frequency, speed, reliability, comfort, safety and train operations (Fazlina et al., 2010).

A new performance index called Transit Service Indicator (TSI) helps to quantify and evaluate the quality of service of a transit system. TSI helps to integrate performance measures such as service frequency, hours of service, route coverage, service coverage, service span, population, jobs, travel demand, capacity, travel time components (walk, wait, transfer and ride), travel speed, average vehicle number occupancy and headway within a systematic framework. It recognizes the need to consider spatial and temporal variations in travel demand. Furthermore, it recognizes the need to consider interaction between supply and demand with a LOS measure. Unfortunately, Fu and Xin's (2007) research did not define LOS using the proposed TSI (Fu and Xin, 2007).

Rahaman and Rahaman (2009) studied the development of a railway model that defined the relationship between overall customer satisfaction and railway service quality attributes based on passengers' perception of a selective route from Khulna to Rajshahi in the southwestern part of Bangladesh. They observed the development of a railway model because the railway is a very popular form of transportation there due to it being cheap and being able to provide pleasant journeys. This railway model was called the overall satisfaction model. In addition to that, the quality of service was the main subject of observation because of high passenger demand. Basically, the factor analysis and multiple regression analysis were used to draw a relationship between satisfaction of service and service quality attributes of rail passengers. The results showed that overall service satisfaction depended on eight service quality attributes such as waiting time for train, space for moving on train, the atmosphere inside the train, security in the train, waiting arrangements, station information, security in the station and behaviours of the staff at the station. In general, the dimensions (attributes) that represented elements pertaining to information such as level of comfort, personal safety, station organization and information and dynamic information were also defined as 'soft' elements. On the other hand, 'hard' elements referred to attributes like accessibility, service schedule, travel time reliability and price–quality ratio (Brons et al., 2009). The overall satisfaction model would aid in determining the overall situation of the existing rail service under different circumstances which would then serve as a guideline in making improvements (Rahaman and Rahaman, 2009).

'The present Indian railways are characterized by challenges of market changes and an increasing demand in capacity' as stated by Bharathi (2010).

Bharathi (2010) looked into the attitude of the Indian railway passengers towards the present conditions of the Indian railway service in meeting the expectations of the customers (passengers). Data collected from field surveys were processed to conduct the factor analysis and multiple regression analysis. The findings depicted that the Indian Railways had to address the most prominent problem such as passengers' comfort inside the train and the least major problems highlighted were the layout of platforms for restaurants, tea stalls, cool bars etc. so as to attract more passengers to ride the trains and to maintain passenger volume (Kim, 2011, Lai and Wu, 2011). Other problems that needed attention in the Indian railways ranged from authorities looking into cleanliness in waiting halls, platforms, compartments, etc., to security arrangement and the concession given to various sections of society. Measures for improvement of the conditions of the Indian railway service were placed in the following categories: amenities and safety measures, facility for reservation, cleanliness and concession and catering (Bharathi, 2010).

Eboli and Mazzulla (2007) identified via the proposed model of an exploratory factor analysis (EFA) that service quality attributes affecting customer satisfaction for bus transit ranged from service planning and reliability, comfort and other factors, safety and cleanliness to network designs. The first variable, service planning and reliability were closely related to the factors of frequency, reliability, information, promotion, personnel and complaints. Comfort and other factors were associated with bus stop furniture, overcrowding, cost, environmental protection and bus-stop maintenance. The third variable, safety and cleanliness were directly related to cleanliness, safety on board and personal security. The fourth variable, network design highlighted bus-stop availability and route characteristics. In short, Eboli and Mazzulla (2007) identified reliability, assurance and tangibles as factors affecting customers' satisfaction in bus transportation services (Annamalah et al., 2011).

According to previous research, service quality means the average time spent by customers in the system (Paolucci and Pesenti, 1999). Indeed, it involved the wait time and journey time experienced by customers. Perceived service quality can be defined as a global judgement or attitude relating to the superiority of the service (Nuraiza, 2000). She also defines it as a measure of how well service level delivered matched customers' expectations while satisfaction with services is closely linked to conformation or disconfirmation of expectations. Perceptions of high service quality during service delivery are indicated by meeting or exceeding customers' expectations. In addition to that, the concept of perceived service quality is viewed in terms of consumers' perception and expectations of services experienced. Likewise, Wyckoff (2001) defines quality of service as a concept where 'quality is the degree of excellence intended, and the control of variability in achieving that excellence, in meeting a customer's requirements' is obtained. Calabrese (2011) states that 'in a service company, an optimal balance between service productivity and perceived service quality is measured by customer perceived quality which is then equivalent to output quality' and that 'it is attained when the highest perceived service quality manages to provide customers satisfaction under a technical efficiency condition.' Output quality measures that have been used for Midway Airlines include reliability, timeliness, comfort, fast baggage service, well-prepared food, knowledgeable and efficient staff (Wyckoff, 2001).

Rail service quality covers the quality levels of various aspects like timetable related features, variability in performance, non-timetable journey related service quality attributes, such as rolling stock, crowding, station facilities, on-board service and information provision, and service quality related to access and egress from the rail network, including the time and cost involved in getting to and from stations of which these aspects describe a rail service (Eboli and Mazzulla, 2012, The Association of Train Operating Companies, 2002). As a result, based on Wyckoff's (2001) research experience, the improvement of service quality process is frequently time-consuming. According to Harris and Baron (2004) and Duncan (2010), however, 'service quality is empirically improved through increased customer participation' or increased ridership. For example, park-and-ride is one of the service quality attributes that provides source of potential riders within a Transit-Oriented Development (TOD) (Duncan, 2010). A station or terminal must be designed to minimize waiting time. The processing time (time waiting) of passengers and vehicles at this station or terminal is the difference between the time of arrivals and the time of departures (Mohd Yusof, 2002).

Since three decades ago quality of service represents the decisions a possible passenger makes when deciding whether to use public transport or other modes through a number of significant research (Transportation Research Board, 2003, Wyckoff, 2001, Lesley, 2009). Quality of service measures are divided into two main categories: availability and quality as shown below in the quality of service framework (Table 2.1). Specifically, Lesley (2009) argued that quality of service measures such as travel speed, ease of access and reliability had been proven to affect transport's mode choice based on past studies in the fields of market and behaviour.

Table 2.1 Service and Performance Measures

Quality of Service Measures	Service and Performance Measures		
	Transit Stop	Route Segment	System
Availability	**FREQUENCY** accessibility passenger loads	**HOURS OF SERVICE** accessibility	**SERVICE COVERAGE** percentage person-minutes served indices
Quality	**PASSENGER LOADS** amenities reliability	**RELIABILITY** travel speed public transport/private travel time	**PUBLIC/PRIVATE TRANSPORT TRAVEL TIME** travel time safety

Source: Transportation Research Board (2003)

Findings were obtained regarding consumer anxiety in Harris and Baron's (2004) research, which encapsulated the phenomenon of consumer anxiety being frequent due to uncertainty about travel times, journey destinations and train station platforms. According to Tandon (2006), passengers' demands on modernized passenger reservation systems using computers and the Internet, efficiency, effectiveness and politeness in service result in anxiety too (Geetika and Nandan, 2010).

Quality of service is part of the LOS, measuring behaviour of passengers, and qualitative service elements like convenience and simplicity of using the system, riding comfort, aesthetics, and cleanliness (Vuchic, 2005, 2007). Cao et al. (2009) in their studies entitled *LOS Classification for Beijing Urban Rail Transit Passages based on Passenger Perceptions* found that 'different pedestrians have different perceptions on LOS'. They were comparing the LOS classification results with LOS criteria for walkways proposed by the Highway Capacity Manual (HCM) 2000. Thus, several literature have shown that 'customer satisfaction has been commonly accepted as an indicator of service quality' (Geetika and Nandan, 2010, Oña et al., 2012, Chou et al., 2011, Chou and Kim, 2009). Meanwhile, factors such as body size, culture, gender and age also affected LOS classifications (Cao et al., (2009).

Service quality will affect customers' satisfaction. Similarly, service quality impact customers' satisfaction levels positively. The relationship between railway passenger service quality and customer satisfaction is strong with the correlation coefficient being 0.537 from the results of path analysis of the Structural Equation Modelling. Path analysis involves testing the relationship between two variables, especially the regression weights for the link between the two variables. The standardized regression weights are the strength of relationship between two factors or variables. Thus, this result was consistent with previous research conducted. The continuous improvement of service quality can increase customer satisfaction (Irfan et al., 2012), reduce customer complaints and enhance customer loyalty (Prasad and Shekhar, 2010b, Tseng, 2012, Chou et al., 2011, Chou and Kim, 2009). For example, high quality service is vital for any service industry because high quality service will help service industries to succeed in their business ventures (Parasuraman et al., 1988, Cavana et al., 2007). This is also supported by Sliwa and O'Kane (2011), Kim (2011) and Chou et al. (2011) where these researchers claimed that organizations should provide high quality services and on-going quality enhancement (Oña et al., 2012, Chou and Kim, 2009). These result in higher customer satisfaction according to Chou and Kim (2009), Chou et al. (2011), Kim (2011), Oña et al. (2012) and Tseng (2012). Rohana et al. (2012) stated that businesses would be successful and profitable if they are able to satisfy customers. Loyalty, higher profitability (Kim, 2011), lower cost (Cavana et al., 2007), 'retained markets, increased use of the system, newly attracted customers (Tseng, 2012), and Chou and Kim (2009) added that, a more positive public image (Oña et al., 2012)' also impact customers' satisfaction levels. Tohidi and Jabbari (2011) concluded that an organization has high quality services if it can surpass customers' expectations. 'However, the existing knowledge about product quality is insufficient to deal with service quality' in service industry outputs with regards to intangibility, heterogeneity and inseparability characteristics (Cavana et al. (2007) based on Parasuraman et al. (1985)). Lai and Wu (2011) further noted that 'the higher the perceived product quality, the higher the customer satisfaction and vice versa'.

Meanwhile, the improvement of customer satisfaction cannot improve service quality (He and Jun, 2010). Railway passenger service quality is determined by a customer's actual perception. Findings revealed that customer satisfaction has a significant effect on customer behaviour intention with the correlation coefficient being moderately strong i.e., 0.35 thus concluding that customer satisfaction can improve significantly via word of mouth and recommendations. In the same development, the relationship between railway passenger service quality and customer behaviour intention was quite weak i.e., 0.193 thus indicating that higher or lower customer perceived service quality can make no difference for customers to change service providers. Overall results indicate that customers perceived railway passenger service quality as having no decisive affect on a customer's travel mode choice.

In Liu and He's (2010) study, the Extended Contributive Rule (ECR) method was used to hierarchically analyze the Shanghai urban rail transit service quality. ECR was an extension of the Simple Contributive Rule (SCR) which can provide more technical information to users. SCR is represented by $g\,(c^{l}_{ij},\ldots\ldots,c^{m}_{ij}) = \sum_{l=1}^{m} c^{l}_{ij}$; where g is a sum of individual preferences *clij*, $c^{l}_{ij} = u^{l}(a_i) - u^{l}(a_j)$, the SCR method can be expressed as $g\,(c^{l}_{ij},\ldots\ldots,c^{m}_{ij}) = \sum_{l=1}^{m} u^{l}(a_i) - \sum_{l=1}^{m} u^{l}(a_j)$; This SCR method provides the preference order of the group reflecting individual opinions and cannot identify degrees of opposing opinions. ECR can determine the different levels of service and can identify the different requirements of various groups of people in the service quality. Liu and He (2010) defined urban rail transit service quality as 'the satisfactory degrees that the rail transit operator's service can meet customers' travelling requirements'. Furthermore, urban rail transit service quality can be divided into service quality and transportation quality. Different levels of service described service quality whilst service quality of the rail passenger transport described the quality of transportation. Liu and He (2010) highlighted six main indices such as comfort, orientation facility, security and easy use of difficult equipment, creditability of train, customer service and man-oriented facilities as a result of the evaluation index of the urban rail transit service quality in the brainstorming process among professional consultants. From the overall results, it can be concluded that comfort was the most important factor and concern for passengers. Pertaining to this, passengers mostly complained about overcrowding in carriages during peak hours. This was followed by the creditability of the train where more than 15 percent of the daily passengers of the Shanghai urban rail transit were more concerned about on-time rate, especially during the morning rush hours. More than 15 percent of the daily passengers involved students and commuting passengers. The major customer group during non-rush hours were passengers above 50 years old and this group was more concerned about the easy operation of difficult equipment at the station, especially the ticket vending machines (TVMs). Meanwhile, the men-oriented facilities or disability friendly facilities were the least important items that passengers were concerned with. This shows that senior citizens and the disabled group did not obtain much attention from the community. The ECR method enabled the rail transit operator to identify service improvement measures by systematically evaluating the views of passengers and then coordinating the conflicting interests between passengers and the rail transit operator to meet mutual agreement.

Yang et al. (2010) stated that public transport service quality describes how customers judge public transport services and literature has highlighted much about public transport service quality research-related to travel behavioural time and money issues. Yang et al. (2010) also proposed that the negative impact of passenger crowding in the psychology perspective be gauged in evaluating the service quality of public transport.

Nuraiza (2000) defined perception as ‘a complex and a dynamic process by which people select, organise and interpret sensory stimulation into a meaningful picture of the world’. She also mentioned that perception is much influenced by attitudes, beliefs, values, motives and past learning experiences. Other definitions for perception are ‘how we see the world around us’ and ‘those processes that shape and produce what one actually experiences’ Nuraiza (2000). The ways in which customers perceive services are highly subjective because perceptions are influenced by many external and internal factors pertaining to cultural, social, psychological and economic aspects. ‘What a customer perceives can differ from reality’ Nuraiza (2000). The customer evaluation of service and future behaviour depends on the perception, not on reality itself. The main objective of urban rail transit is to improve the actual perception of passengers towards services constantly (Cheng and Yan, 2008).

Nuraiza (2000) defined consumer expectations as the pre-trial beliefs a consumer has about the performance of a service. These beliefs are used as the standard or reference against which service performance is judged. Customers evaluate service quality by comparing what they want or expect with what they perceive they are getting (Prasad and Shekhar, 2010a). Customer dissatisfaction would occur if expectations are greater than performance whereas perceived quality is less than satisfactory (Prasad and Shekhar, 2010a).

One can judge the service quality of a public transport network by its waiting and travel times. For example, better service delivery can be measured by more frequent and prompt services (Frumin, 2010).

Most passengers make more trips per week and are dependent on trains in metropolitan Lagos. However, only 18.1% observed the nature of the arrival time as good whereas above 80.0% confirmed that the smoothness of train rides and the cleanliness of the coaches particularly the toilets as being poor and inadequate (Agunloye and Oduwaye, 2011). Thus, the research concluded that even if passengers were very much dependent on trains, only 18.1% admitted services were punctual. This highlighted the train's inefficiency which needed improvement. This percentage was approximately threefold (i.e. 3.62 times) higher than the Malaysian *KTM Komuter*. Only 5.0% deemed its punctuality good.

Liu and Guan (2009) pointed out that railway passenger transport must improve its passenger service quality to compete in the transport sector. To achieve this, it is important to undertake evaluation research on the quality of the railway passenger service in order to rank both the attribute weights and attribute values of the service, so that service quality can be improved. According to Liu and Guan (2009), international practices were primarily conducted by customer satisfaction surveys. Customers' choices are complex and changeable to situations and have often resulted in service quality evaluation indicators being always almost accurate, hence, implicating decisions that are precise enough. Based on a similar research in literature, Liu and Guan (2009) proposed railway passenger service quality evaluation indicator systems to include ticketing and waiting service qualities, punctuality, comfort and security indicators together with exit service degree applying linguistic variables and the improved PROMETHEE-II method.

Tukis and Nizamuddin (2012) did a similar research but it was due to *KTM Komuter* encountering overcrowding and lack of space comfort in the train and at the stations during peak hours, where passengers had to queue for a long time to get the tickets. Ticket vending machines were inadequate and sometimes malfunctioned, passengers felt it inconvenient to transfer stations because of poor walking facilities.

These researchers solely surveyed *KTM Komuter* passengers at the Kepong Sentral and Mid Valley stations and they focused on service attributes such as punctuality, frequency, speed, space, comfort, fare level, cleanliness and safety. They carried out both traditional and online surveys and observations onboard trains, at the stations and analysed the operation of the *KTM Komuter*. The total sample involved 120 questionnaires. 68.3% of the respondents were female. 54.2% and 25.0% were Chinese and Malay commuters, respectively. The highest proportion of age group was between 21 and 35 years (55.8%), 26.7% were in the age group of 36-50 years and 10.8% involved respondents below 20 years old. For occupation categories, 43.3% were students, 30.0% were private staff and 23.3% were government staff. As high as 35.8% of the respondents transferred stations to take either LRT, KL Monorail, bus for shopping purposes. 21% of them rated fares as reasonable, 20.0% rated the train coaches and stations as clean, 17.0% were satisfied with train safety, 14.0% felt comfortable with services, and some respondents were extremely dissatisfied with train punctuality, frequency, speed and onboard overcrowding. Tukis and Nizamuddin (2012) recommended that *KTMB* provided large and more trains at greater frequency to accommodate more passengers in the future.

Another similar research was undertaken by Rohana et al. (2012) who investigated users' expectations towards public transport services in the Klang Valley and its relationship to customer satisfaction, loyalty and environmental factors by using SEM. They also attempted to determine the most preferred mode of public transport. Primary surveys conducted at various bus and train stations around Klang, Shah Alam, Subang Jaya, Petaling Jaya, KL, Gombak and Ampang resulted in most of the respondents (20.0 to 30.0%) preferring to ride on the rail transport systems rather than bus. Similar results were reported in UK and Delhi by Jain et al. (2014) on aspects of comfort amongst commuters using public transport. The commuters preferred comfort in terms of accessibility, less travel time, less crowd, availability of seats, cleanliness, low floor and air conditioned features. The commuters considered public transport as stressful because of its unreliable and low-frequency service. Hull (2005) highlighted a case study of Malmö to show the success of the Sweden integrated transport strategy as early as 1970s in promoting public transport as a key theme of environmental strategy. As such, Malmö strategised low floor, low emission buses, security and customer information improvements, bus integration with car-pools, cycling and walking facilities, access restriction to the central city for commercial and heavy-duty vehicles, priority access in many areas of the city for buses and electric vehicles, and free parking in the city for electric vehicles. Kumar et al. (2004) also employed part of the present research to understand the perceptions of rural bus users towards different service attributes and to model GTC.

Multimodal transport comprises at least two vehicular modes of transport, representing a common form of urban travel in association with sustainable transport (Amiruddin et al., 2012). According to Curl et al. (2011), the common barriers in multimodal trips to access destinations ranged from cost, transfer and reliability of services.

According to Tukis and Nizamuddin (2012), transferring stations often require active travelling on foot using staircases, escalators and pedestrian crossings on busy junctions. There were some cases pertaining to the physical integration of the modes where the users had to transfer to monorail and express buses at different stations because the buildings of the stations were constructed in other locations. For example, the exact position of the nearest monorail station is 140 metres from the KLS or less than 15 minutes walking (transfer) distance because of places crowded with pedestrians. These pedestrians had to cross a traffic light junction; The Putra *KTM Komuter* transfer station is situated 400 - 500 metres from the PWTC LRT station and the public cross busy main roads fixed with several traffic signalized junctions (or between 15 minutes and 20 minutes walk away) and 300 metres from the Putra Bus Terminal (or 10 minutes walk at the least), requiring users to be on foot along the footpath over an expressway and a ramp. The Putra Bus Terminal operates express buses to the east coast destinations. These locations regularly created confusion especially to inexperienced public transport riders often resulting in discomfort and inconvenience for riders (Agarwal, 2008).

More unfortunately, the Masjid Jamek LRT stations are not directly integrated with each other for both the Kelana Jaya Line and Ampang/Sri Petaling Line due to the corresponding type of railway track, which have caused the construction of separate station buildings. Within this Masjid Jamek area, the Kelana Jaya Line is an underground system whereas the Ampang/Sri Petaling Line has a grade separated structure. Therefore, transfers between LRTs and buses had the worst transfer penalty due to extra walking distance to some stations and grade separations. The results of a Singapore's Stated Preference survey in 2004 by Yew (2008) mentioned this. Yew (2008) and Syahriah et al. (2013) emphasized that integrated transportation terminals or hubs are essential infrastructure to mitigate the transfer penalty between bus and LRT/LRT and bus. This is similar to Spain where the intermodal exchange stations were introduced to allow quick and easy transfers as highlighted by Chowdhury et al. (2014). Furthermore, two integrated or intermodal transport terminals (ITT) would supposedly be operating soon in Bandar Tasik Selatan and Gombak within the Greater KL primarily to overcome the intercity bus congestion at the urban fringe of city centre (The Economic Planning Unit, 2010). So, the related transfers have also been accounted for in these modal integrations (Grotenhuis et al., 2007). Moreover, transit users had to make a series of waiting and walking trips to execute one of the aspects of transfer journey experience or activity of travel (Wardman et al., 2001).

The afore-mentioned findings suggest that transfer is a very important design component in integrated multimodal public transport network (Chowdhury et al., 2014) planning, design and operation (Yew, 2008) and should be made comfortable and convenient so as to boost public transport demand (Jamilah, 1997, Shamsul, 2008) and revenue, and to prioritize the needs for the general public (The Economic Planning Unit, 2010). Hine and Scott (2000), Wardman et al. (2001), Muhammad Faishal (2003), Preston (2012a) and Chowdhury et al. (2014) stressed that transfer facilities should continuously be improved to enable seamless travel as part of a user-friendly integrated public transport system network. Nazery (1997) also supported that improvements in multimodal linkages and integration will encourage economic growth for efficient transportation of goods in the country. In choosing the route for public transport trips, users would consider simple, short, direct journeys, with high-frequency services at minimum weighted travel time (Larrain and Muñoz, 2008, Albrecht and Howlett, 2009) and waiting time (Sparing and Goverde, 2013), that is, its time costs varies with the levels of comfort and convenience or ease (Wardman et al., 2001) and also takes into account that the alternative routes have the same travel costs. Users normally disliked and got frustrated experiencing/making multiple transfers (Larsen and Sunde, 2008, Yew, 2008, Mackett et al., 2006). Users prefer to avoid transfers throughout their public transport trips according to Hine and Scott (2000) and Wardman et al. (2001). Hine (2002), Muhammad Faishal (2003) and Chowdhury et al. (2014) stated that the improvement in multimodal transport network integration could reduce wasteful duplication of services thus leading to improved transport and land resources. They further stressed that an improved public transport integration in general can ease people's mobility and accessibility together with low costs of transfers and operation, a cashless public transport system if effective fare integration is practised. Meanwhile, Hine and Grieco (2003) pointed out that people's activities at every hour of the day had significant impacts on mobility and accessibility.

Chowdhury and Chien (2002) confirmed that users perhaps cannot avoid one or more transfers to get to their destinations because of modern intermodal infrastructure or means of modal integration which are widely spread in the cities. A successful example of this was the higher use of integrated German public transport highlighted by Chowdhury et al. (2014) where transfers made users move quicker and easier. This was also supported by Sparing and Goverde (2013) that transfer connections were still to be included in the low frequency lines within the public transport network. Tahmasseby et al. (2007), Larrain and Muñoz (2008) and Ceder (2007) also agreed with the fact that the number of transfers should be minimized on the public transport network design since it is the root of disregularity and dispunctuality of unreliable operations. Sparing and Goverde (2013) opined that transfer waiting time should be minimized to make public transport networks more attractive. Another instance is depicted in a study conducted by Mohd Rashid (2008) that proposed that railway stations within KL, Selangor and Negeri Sembilan be exclusively integrated to influence constant periodic journey time and to increase its frequency for reliable services. Otherwise, the related time pressure would imply degraded LOS thus causing dissatisfaction and discomfort to fellow passengers such as, inaccuracy of *KTM Komuter's* arrival time, departure time and dwell time (Frost et al., 2012) together with inadequate audible announcement systems (Amri, 2008, Harmize, 2008). Thus, Chowdhury and Chien (2002) verified that transfer penalties can be lessened greatly to enhance service quality by synchronizing the schedules of various public transport modes. This highlights the need for proper coordination of such modes by seeking optimal headway and by ensuring effective holding times to compensate potential late connection, resulting in minimal transfer and operating cost (Chien, 2005).

Meantime, the multimodal transport in this context embraced the number of all modes of transports for door-to-door trip, particularly from the ultimate origin (the house) ending at the final destination (the office or workplace). This also caused many public transport users to undergo very long non-ride time thus impacting total travel times. Mohammad (1989) stated that walking, transferring and waiting were non-ride activities, which result in a journey being less smooth. Transfer time at transfer nodes subsequently implicated the real functions of walk and wait times to complete the change to the connecting transport mode thus increasing the intricacy of a journey for first-time passengers (Transportation Research Board, 2013). On top of that, O'Dell and Wilson (1997) validated that on-board time also played an integral part in the waiting environment. However, the typical criterion for a standard transfer in designing service at planning level is between one and three for a maximum number of transfers for any trip based on the United States data (Ceder, 2007). The same transfer concept applies to the Australian and Singaporean urban public transport networks (Scheurer and Curtis, 2008, Yew, 2008). Transfer enabled users to change modes in a multimodal trip and it should be minimized to one as it troubled users in terms of lost time, additional costs (van Nes, 2002), uncertain travel time (Goverde, 2005) and longer travel distances, as well as unattractive multimodal transport service with regards to poor reliability, exhausting journey and higher travel costs in the KL context (Larsen and Sunde, 2008, Goverde, 2005, Gray and Hoel, 1992). Mohammad (1989), however, stated that ideal or pecuniary public transport trip with no means of transfer and waiting time were users' preferences based on the concluding remarks of the present attitudinal surveys. According to Chowdhury et al. (2014), comfort at the transfer stations can only be obtained if basic amenities like seating and shelter are provided.

The local public transport integration strategy in 2003 proposed that a minimum of two transfers for each trip with transfer time (or lost time in transfer) should not exceed 3.5 minutes and the walking for transferring efficiently between two connections should be restricted to less than one minute for a 60-metre distance.

The integrated user-friendly feeder bus services operated wholly by the *KTMB* would greatly reduce the effective inconvenience and difficulty experienced by *KTM Komuter* users when good implementation of an integrated fare system and feeder bus users are given priority to access stations. LRT systems have already implemented fare integration with KL Monorail (Syahriah et al., 2008) and this has benefited users in their travel (time and service price) costs. For example, the Touch 'n Go travel card has been accepted for all *Rapid KL*, NadiPUTRA, Ampang/Sri Petaling and Kelana Jaya lines, *KTM Komuter*, KL Monorail and Express Rail Link (ERL) lines since August 2005. The Touch 'n Go card is only RM10 (£2.06). *RapidKL* and *Prasarana* introduced the use of the *RapidKL* RM150 (£30.90)/month Integrated Pass for seamless unlimited rides using *RapidKL* buses, LRTs and KL Monorail since December 2009 (TRANSIT, 2009). Holders of RapidPass will save up to 50% in their travel cost.

For rail-based TOD and planning, the guidelines for standard walk distance are 300 - 900 m in Canada with variations across cities, 800 m in Singapore; 400 m (5 minutes walk) is assumed equal to walking speed of 80 m/min to LRT stations and 800 m (10 minutes walk) to train stations gazetted by the Department of Transport, Queensland Government in Brisbane in 1999 and 400 - 800 m in the United States or typically no more than 15 - 20 minutes of walking time in the China and Singapore context (Rastogi and Krishna Rao, 2003; Wibowo and Olszewski, 2005; Yigitcanlar et al., 2007; Yew, 2008; Moniruzzaman and Páez, 2012; Jiang et al., 2012; Zhao and Deng, 2013).

In general, access facilities should be improved in order to provide greater benefits for rail users (Brons et al., 2009; Moniruzzaman and Páez, 2012). According to this buffer-distance fix at the national planning level, the government was forewarned that the current rail systems were problematic in terms of accessibility and connectivity compared to bus systems and this has been the causal factor for the poor capability of the rail operators to service the general public (Kuala Lumpur City Hall, 2005). Román and Martín (2011) also reported on a similar issue with the intermodal connectivity in Spain. On top of that, many individuals who lived or worked within that distance had not benefited from the *KTM Komuter* services in the study areas (Shamsul, 2008) and this resulted in the Kuala Lumpur City Hall initially planning for feeder services in 1996 and then appointing a local transport consultant by the government to handle a 5-kilometre feeder route length with 400 metres to be the radius of route catchment coverage from the bus-rail integration stations (BRIS) in 2003. Therefore, the topical results of access-egress distances proved that even the 5-kilometre feeder route length was unserviceable to ensure sufficient accessibility and to facilitate public transport availability and connectivity. The relative feeder route length should be tripled (i.e., 15.0 kilometres) to that of the results of studies done in 2002 to address the continuing limited coverage of *KTM Komuter* services.

The waiting time for connecting buses and/or rail systems actually contributes to the crucial consequence of a very long uncertain total multimodal travel time due to its role as part of the transferring process between the main intermodal stations for a variety of bus and rail systems' services. Users' experience impatience, tiredness, frustration and stress (Yang et al., 2010, Nor Diana, 2012) over unreliable train operations yielding direct affects to the varied capacity utilization of the coaches and platforms in the absence of adequate electric multiple units (EMU) and their coaches (Goverde, 2005) during peak hours (Nor Diana, 2012). In view of this, the analysis on in-vehicle time, user waiting time and journey time due to additional users must be taken into consideration in designing better *KTM Komuter* services (Larrain and Muñoz, 2008, Hu et al., 2008, Huang and Niu, 2012). Unexpected and overwhelming demand and operation technical faults have brought about increases in load (crowding) levels (Nor Diana, 2012), uncertainty about trips at both station platforms and on train coaches (Syahriah et al., 2013; Transportation Research Board, 2013), congestion at doors (Harmize, 2008, Hirsch and Thompson, 2011, van Oort and van Nes, 2010, Takagi et al., 2006), longer waiting time (O'Dell and Wilson, 1997), and the inconvenience of use.

2.4 CONCLUSIONS

The present research developed a conceptual model of service quality where dimensions and items were derived for the KOMIQUAL scale. The nine dimensions identified were: Train Ambience, Ticketing System, Parking Facilities, Train Efficiency, Station Quality, Soft Services or Skills, Facilities, Space Comfort and Rail Structures. In this research, the nature of the nine dimensions derived differed from the five dimensions in the study by Parasuraman et al. (1988). In summary, the current findings add to a growing body of literature on rail service quality thus enhancing a researcher's understanding of the role of methods such as Factor Analysis and SEM. Besides, the KOMIQUAL scale is a reference for defining high *KTM Komuter* service quality by *KTM Komuter* management optimising its service provision and being customer-oriented (Liu and Guan, 2009; Too and Earl, 2010; Lai and Chen, 2011; Filippi et al., 2013) (Irfan et al., 2012). This research extends the existing body of literature by examining, modelling and then optimising *KTM Komuter* service patterns and their operating environment in terms of service frequencies and fleet size as well as fares. The Transportation Research Board (2013) has demonstrated that the key concerns of service capacity and quality of service are operating environment and service patterns.

A systematic and in-depth review of key research and literature identified the need to conduct the present research at doctorate level. A systematic and in-depth review of key research and literature has also assisted in the further development and refinement of both the problem statements and the hypotheses.

CHAPTER 3 : METHODOLOGICAL REVIEW

Chapter 3 presents a review of available methodologies such as Public Transport Demand models, Attitudinal models and Optimisation models. Some theoretical details of elasticities and values of time under public transport demand models are made available. Subsequently, the literature in relation to Attitudinal models is briefly reviewed. In the current research, basic statistical techniques such as factor analysis and the Structural Equation Modelling method with Analysis of Moment Structures (AMOS) are used in combination to draw a relationship between service quality attributes of rail passengers and high *KTM Komuter* service quality. Optimisation models, economic optimization, economic mathematical optimization approaches and Optimisation models with effect of negative externalities are introduced in the following sections. Combined factor analysis and optimisation are discussed in the last section.

3.1 INTRODUCTION

Public Transport Demand models were analysed to forecast rail demand for rail transport network planning and management. Public Transport Demand models include some variables of the quality of service. However, problems were encountered in distinguishing variables defining demand and variables defining quality of service. These models were estimated based on time series analysis, and revealed-preference (RP) and stated-preference (SP) work from passenger surveys.

Attitudinal models were analysed to model and forecast both the attitude and behaviour of rail passengers for rail transport network planning and management, the company's (rail operator's) overall performance and for marketing purposes.

Optimisation models were analysed using an economic optimisation approach to gauge optimized (or optimal) service patterns of *KTM Komuter* in the form of quantity of service (identified as supply functions) such as service headway, vehicles and fares.

3.2 PUBLIC TRANSPORT DEMAND MODELS

The coverage of Public Transport Demand Models is limited to those mentioned in accordance with the Passenger Demand Forecasting Handbook, PDFH (The Association of Train Operating Companies, 2002). These models are realtively simple elasticity models or calculations, which are straightforward and do not require any computer software. They are simple to apply because they utilise short mathematical formulae. However, they are several weaknesses according to some transport professionals. Such weaknesses are in relation with the feature of the models i.e., their static nature around which constant elasticities of demand and rail attributes are applied and their specific cornerstone is on the demand side. The contents of PDFH have been improved over time and used in investment, marketing, fare setting, timetable efficiency and operational planning. The PDFH is the best practise demand to forecast aggregate demand changes for rail practitioners usage when general effects of service , quality, fares and external factors (such as Gross Domestic Product, GDP) are considered. The PDFH summarises parameters ranging from external environment, fares elasticities, journey or station to station time-frequency-interchange (transfer), reliability, non-timetable related service quality, new services/access to competition between operators. Their parameter values vary significantly for reasons like journey distance and purpose, GDP, ticket type, flow type, income and competition. In addition to that, parameter values vary significantly based on regions viz. London Travel card area, South East, Rest of the country to London flows (by distance bands), Non-London Inter-Urban flows with/without full set of tickets (by distance bands), Airports and Rest of the country. Simple and more complex forecasting examples and their applications are provided at the end of every chapter (Shires, 2006).

There are two key approaches to modelling public transport demand in a general procedure i.e. the multi-stage method and the direct demand models (The Association of Train Operating Companies, 2002). The multi-stage method involves a traditional four-stage method ranging from trip generation, trip distribution, mode split and trip assignment. Although this method is commonly applied at national levels, it has a number of major disadvantages for rail demand forecasting. These disadvantages include the fact that the models are costly to calibrate, validate and apply, as they require data on all transport modes and need expertise. Its modelling set up is also not robust, thereby forecasting results are least accurate and the model is poor in forecasting newly generated trips causing insignificant improvements. As a consequence, much simpler methods are employed i.e. the direct demand models in the form of a single equation for most rail demand forecasting.

Three of the most widely used types of model are briefly described. They are a simple elasticity model, a public transport assignment model and a random utility model.

A basic characteristic of the simple elasticity model is that it treats the demand for public transport as a function of the price and travel time, taking into consideration no account of price and travel time of competing modes. No detailed data on competing modes means the simple elasticity model may only be suitable for estimated public transport assessments. Let us specify a simple elasticity model encompassing the generalised cost, G as the basic demand-determining variable to be written as follows according to (Jansson and Mortazavi, 2000):

$$x = V \exp\left(\frac{-a}{b} G^{b}\right),$$

where,

$x =$ Demand,

$V =$ a scale parameter including the unknown factors,

$a =$ the level of the elasticity, and

$b =$ the dependence of the elasticity on the generalized cost.

Thus, the elasticities with respect to generalised cost, ε_G and prices, ε_P, respectively are

$$\varepsilon_G = -aG^{b} \text{ and } \varepsilon_P = \frac{P}{G}\left(-aG^{b}\right)$$

Parameter b denotes some special features when there is <u>a reduction in generalized cost</u> (an assumption):

If $b>1$, the elasticity will decrease but the differential of the elasticity with respect to generalized cost will decline;

If $b=1$, the elasticity will decrease and the differential of the elasticity with respect to generalized cost is constant; and

If $0<b<1$, the elasticity will decrease but the differential of the elasticity with respect to generalized cost will increase with generalized cost.

The above demand, x equation can be modified to consider the public transport share, s_{pt} for origin-destination zone pairs as follows:

$$x = V \exp\left[s_{pt}^{c} \left(\frac{-a}{b} G^{b} \right) \right]$$

The corresponding elasticity with respect to generalized cost is $\varepsilon_G = -s_{pt}^{c} a G^{b}$.

Parameter c suggests the following characteristics:

If $c>1$, the elasticity varies less than proportional to the public transport share;

If $c<1$, the elasticity varies more than proportional to the public transport share; and

If $c=1$, the elasticity varies proportional to the public transport share.

A public transport assignment model distributes the demand for each public transport service and mode based on travel time and sometimes price of each service and mode (Jansson and Mortazavi, 2000). A basic characteristic of the public transport assignment model is the assumption that each passenger will choose the alternative that has the lowest generalised cost without considering the unknown attributes. This type of model is usually deterministic with some randomness allowed with respect to the application of departure times that are assumed linearly distributed. The outputs of this type of model are used by the random utility model particularly for distribution among routes and/or modes.

An all-or-nothing (AON) assignment model is developed using the frequency-based modelling approach to simulate a deterministic path or route choice. This AON assignment model is also characterized for the public transport traveller's route choice on the basis of the concepts of optimal strategy and hyperpath (Crisalli, 2003). The AON assignment method practises the least cost criterion while allowing only the least cost lines of the hyperpath to be loaded and it calculates the transition probabilities (Schmöcker and Bell, 2002). The frequency based models should not use an average passenger number similar to that of the origin points at the transfer stops as this value corresponds to the frequency of single lines. The subsequent calculation will cause most of the assignment models handling the problem of transfers to be inaccurate (Horváth, 2005).

A common line problem always causes passengers feeling uncertain about their decision in either taking the next vehicle on a line or waiting for a more attractive line (Bell, 2003). If passenger arrivals and/or vehicle departures are randomly estimated, the common line problem is easier to handle with frequency-based models. Waiting together with passengers who have already waited for some time and those who have just arrived and alighted, which happens temporarily or at least to certain extent on platforms, can however be more easily and accurately represented by a frequency-based model (Schmöcker and Bell, 2009). It can be justified by the passenger behavioural hypotheses that passengers often change their pre-trip stop (or station) and route choices en-route and decide line choices en-route for the operations of urban traditional public transport systems (Nuzzolo, 2003). The typical urban traditional public transport system for its greatest impact is high-frequency service with no user information at stops. This implies that the frequency-based model might be able to reflect passenger route choice behaviour better in some circumstances considering optimal strategy. Schmöcker (2006) stated that passengers develop strategies as introduced by Spiess and Florian (1989) if more than one transit line leads to their destination. Using a probabilistic route choice model, a stochastic public transport network loading could estimate the corresponding choice probability for all lines that are loaded within all hyperpaths in the set of choice.

Although it is assumed that the line frequencies are constant and there are no effects of congestion on public transport services in the traditional frequency based models, the actual line frequencies are affected by the level of congestion of the public transport network due to the fact that they are related to the cycle journey times of the public transport vehicles. Such journey times of public transport vehicles are also affected by congestion levels (Lam et al., 2003).

After examining a criterion based mode on the profile-based load for the selection of either the point-check or the ride-check method, two methods of maximum load (point check) derive vehicle frequencies to ensure sufficient space to support the maximum on-board passengers at more than one selected public transport stops (stations) along the route over a given time duration are selected. These methods are selected for public transport data collection in order to incorporate practical operational considerations (actual observed data from field or on-site measurements and surveys) in the analysis. More importantly, the method that has been carefully selected should allow for an effective and efficient improved level of service quality. The basic premise here is that such a method should be able to either explicitly or implicitly derive the practical frequencies-headways-setting and the applicability of a sensitivity analysis. Therefore, a planner or the train operator could evaluate the minimum expected vehicle runs and partly minimize overcrowding simultaneously (capacity problem). A maximum load point at the stop other than multiple peak points is marked by the average maximum on-board passenger load departing at the stop. The number of vehicles required for the time period j (usually an hour) typically applying the concept of peak load factor. The main output data for every vehicle passing the stop, range from vehicle loads, arrival and departure times, and vehicle type and route location. End points are necessary to be examined to measure running time and farebox readings. Transfer and interchange time, and observational studies can be performed at strategic points (Ceder, 2007).

The approach presented by Spiess and Florian (1989) is discussed as a feasible frequency-based public transport assignment because of the previous strategies by other researchers that have had led to a sub-optimal solution. Spiess and Florian showed that passengers can often significantly reduce their travel time when they have several paths to their destination. Point-check passenger counts are carried out several times a year since it is a more appropriate and less expensive method for data collection (Ceder, 2007).

A random utility model involves passengers being distributed based on a function of travel time and price of the alternatives. The distribution is also a function of unobserved influences. The focus on this section will be on the most widely used model i.e. a discrete choice model such as a multinomial logit model. A multinomial logit model can estimate a modal choice model. A simple method can sometimes estimate public transport route choice and user benefits. The one and only unique feature of the multinomial logit model is an assumption of a random component (disturbance term) to be independent and identically distributed (IID).

3.2.1 Elasticities

Elasticities are one of the key concepts in transport demand forecasting. In Oum and Waters II's (2000) study, an elasticity is defined as a measure of responsiveness. Specifically, 'it is the percentage change in one variable in response to a 1% change in another'(Oum and Waters II, 2000). It is referred to in the Rail PDFH, The Association of Train Operating Companies (2002) as 'an elasticity is the ratio of the percentage change in rail demand to the percentage change in the factor affecting demand.' Elasticity is said to be positive when an increase in the factor leads to an increase in demand. The elasticity is said to be negative when an increase in the factor reduces demand by a certain percentage. Elasticities' values of up to ±10% are acceptable in many cases.

In the Malaysian scenario, the elasticities concept can be demonstrated and described in the following example of simulation results for mode shares under a different policy of the national stated preference surveys (Malaysia Institute of Transport, 2010).

Stated preference surveys were carried out on 1,964 respondents in the Central Region (Klang Valley and Seremban). The stated preference surveys were carried out in order to solicit the required information necessary to model mode choice behaviour. These surveys identified the respondents' preference in using particular modes of transport for the purpose of going to work in the town/city centre. The choice made was on the assumption that an efficient public transport service is to be provided in the future. The surveys were conducted over a course of one month, from June 2 through July 4, 2008. Face to face interviews were performed on sampled respondents at housing areas, shopping complexes and government offices. A total of 115 enumerators were involved in the survey which recorded responses in the 15-minute interviews. Samples within each location were selected by using convenient sampling technique. These surveys applied the convenient sampling technique partly because prior observations had revealed that as long as the selection of the respondents were not biased towards or against certain user groups, such sampling method could be used for drawing inferences about the target population. The sample size for the whole Klang Valley was 1,964 providing a precision level of 1.9% (this 1.9% was calculated on the basis of the sample size for proportion).

Simulation results for mode shares under different policies appeared to be very logic. For example, a reduction in public transport fare could attract about twice as many motorcyclists as compared to motorcar drivers. When the fare was reduced by

50%, the motorcycle mode share dropped by 6% while the respective reduction in car mode share was only 3%. An improvement in the public transport service would also have a more significant impact on motorcyclists as compared to motorcar drivers. Another policy was when the public transport travel time was reduced by 50%, the share of motorcycle dropped from 14% to 8% (i.e. a 6% drop) whilst it affected the share of cars approximately with a 1% drop. Results indicated that reducing fare and travel time both by 50% only increased public transport share by 10%, from 15% to 25% (but the share was up two thirds – assuming fixed total demand, this would suggest an elasticity with respect to generalised cost of around -1.33). Reduction in public transport fare and increase in service level alone was not sufficient to improve public transport ridership. Therefore, private transport demand restraining measures are important for achieving greater use of public transport. However, these must be implemented in conjunction with public transport service improvements.

3.2.2 Values of Time (VoT)

It is the money value of in-vehicle time that is dealt with when it refers to the PDFH, (The Association of Train Operating Companies, 2002). VoT can be interpreted as “the reduction (or increase) in fare as required to compensate for a one-minute increase (or reduction) in journey time” (The Association of Train Operating Companies, 2002). The same reference showed that two of the popular uses for VoTs are to convert Generalised Journey Time (GJT) into monetary units when one wishes to examine the generalised cost of rail travel and to represent main attribute weights or travel time coefficients such as walking time, waiting time on the platform, in-vehicle time and transfer time (Ceder, 2007). In the latter case, the convention has been to value walk and wait times at twice the rate of in-vehicle time, but the Malaysian VoT's are estimated by adopting values of time for the UK which are provided in the government's Web Transport Analysis Guidance (WebTAG) Unit 3.5.6 (Department for Transport, 2012) and it takes into account the differences in average incomes between the two countries. The 2010 prices and values were selected because the survey data was collected in 2010. The British ones were converted using the following steps:

Divide British value of time by British average income;

Multiply the result by Malaysian average income; and

Convert from British pound sterling (GBP) to Malaysian Ringgit (MYR) based on the current exchange rate for 7th. November 2012 using currency converter on the Google website.

Some sample calculations are as follows:- using values from Tables 1 and 2 (Department for Transport, 2012)

The average monthly income per capita for Malaysia in 2012 was MYR1182 whereas the average monthly income (household) in the UK reached £2,150 in May 2012.

Value of Working Time per person from Table 1 is £39.65 per hour, 2010 prices and values for perceived cost and rail passenger. By implementing the above steps,

$$\frac{\pounds 39.65}{\pounds 2150} = 0.018442 \times \pounds 258.08 = \pounds 4.76 = \text{MYR}21.80;$$

Values of Non-Working Time per person from Table 2 are £6.46 per hour, 2010 prices and values for Commuting and £5.71 per hour, 2010 prices and values for others. Implementing the above steps will result in

$$\frac{\pounds 6.46}{\pounds 2150} = 0.003005 \times \pounds 258.08 = \pounds 0.776 = \text{MYR}3.55; \text{ and}$$

$$\frac{\pounds 5.71}{\pounds 2150} = 0.002656 \times \pounds 258.08 = \pounds 0.685 = \text{MYR}3.14.$$

Some sample calculations use values from Tables 1 and 2 (Department for Transport, 2014). These tables were revised and can be seen in WebTAG Unit A.1.3.1. The average monthly income per capita for Malaysia in 2012 was MYR1182 whereas the average monthly income (household) in the UK reached £2,150 in May 2012. These average monthly incomes were also applied to easily compare the calculations made. Convert from British pound sterling (GBP) to Malaysian Ringgit (MYR) based on the current exchange rate for 7th. February 2015 using currency converter on the Google website.

Value of Working Time per person by Mode from Table 1 is £26.86 per hour, 2010 prices and values for perceived cost and rail passenger. By implementing the above steps,

$$\frac{\pounds 26.86}{\pounds 2150} = 0.012493 \text{ X } \pounds 258.08 = \pounds 3.22 = \text{MYR}17.45;$$

Values of Non-Working Time per person by Trip Purpose from Table 2 are £6.81 per hour, 2010 prices and values for Commuting and £6.04 per hour, 2010 prices and values for others. Implementing the above steps will result in

$$\frac{\pounds 6.81}{\pounds 2150} = 0.003167 \text{ X } \pounds 258.08 = \pounds 0.817 = \text{MYR}4.43; \text{ and}$$

$$\frac{\pounds 6.04}{\pounds 2150} = 0.002809 \text{ X } \pounds 258.08 = \pounds 0.725 = \text{MYR}3.93.$$

3.3 ATTITUDINAL MODELS

3.3.1 Bried Review of Previous Studies Related to Travel Behaviour

There is vast literature on travel behaviour, but the practical experience as to whether and to what extent new technologies and public transport system can change travel behaviour is rather limited. However, many are quite relevant to the current study and a few of these provide a brief introduction to some of the questions examined and the work carried out in this area.

A review of existing literature indicates that the current LOS thresholds for determining each of the service measures in the Transit Capacity and Quality of Service Manual (TCQSM) are mainly based on the collective judgment of the **Transit Cooperative Research Program** (TCRP) Project A-15A team and panel. TCQSM is a technical manual published by the Transportation Research Board (TRB) of the United States in 2003. One key element that has not been adequately addressed is how rail users perceive quality of service. Since LOS is widely used as a basic performance measure to evaluate the planning, designing, and operational aspects of rail services, it is critical to consider to what extent this measure reflects the passengers' point of view.

3.3.1 (a) Context of Travel Behaviour

Harvey et al. (1998) mentioned that the challenge facing travel behaviour research is to understand such behaviour and to model it. However, they argued that the key to understanding such behaviour and to model it is the identification of the significant dimensions of behaviour and their interactions. Pas and Harvey (1997) stated that the identification of the dimensions can be done in one or a combination of approaches. The first, is concentrating on activities that occur on a level apart from and above day to day activity, while the second is by focusing on one or another subset of day to day activities such as journey to work, shopping behaviour, social visiting or other activities taken independently of the day to day pattern of the overall activities in which they occur.

Chapin (1974) saw activities as classifiable acts of behaviour that could be used to examine urban behaviour and 'urban activity system' as an umbrella term for the patterned way in which individuals, households, institutions and firms pursue their day in and day out affairs in a metropolitan community and interact with one another in time and space. He found time as the common denominator for linking the various subsystems of the overall activity system. An activity pattern is '*a tendency for a population to behave similarly'*. This applies to each subsystem: households, institutions and firms alluded to above. Initially, Chapin (1974) stressed choice or preference factor as individual behaviour. Later, he recognized that, while motivation and choice may be sufficient to create propensity to act, the outcome or activity was also dependent on the opportunity to act. Instead of viewing the behavioural sequence entirely as a 'demand' phenomenon, the consummation of an activity is seen to be dependent on a 'supply' consideration as well.

Hägerstrand (1970) on the other hand, viewed behaviour 'entirely from the point view of constraints'. Specifically, he saw three kinds of constraints operating. 'Capability constraints are those which limit the activities of the individual because of his biological construction and/or the tools he can command'. These incorporated such circumstances as sleeping and eating requirements, and getting access to a car, etc. 'Coupling constraints defines the where, when, and for how long the individual has to join other individuals, tools, and materials in order to produce, consume and transact'. Finally, there are authority constraints operating in domains 'within which things and events are under the control of a given individual or a given group'. These include private property, zoning regulations, store hours, or even a favourite chair or a place in a queue. While Hägerstrand (1970) viewed activities as occurring within an opportunity set defined by these several constraints, Cullen et al. (1972) viewed activities as occurring within bounds set by both spatial-temporal constraints or fixity and by preferences or priorities. This approach combined aspects of both the motivational-choice mechanism of Chapin (1974) and the constraint approach of Hägerstrand (1970). Cullen and Phelps (1975) later saw behaviour as an 'interactive' function in the social, economic and physical context in which it occurs.

Each of the foregoing approaches represented an attempt to understand and explain human behaviour. The Organisation for Economic Co-operation and Development (1997) also indicated that travel behaviour was only marginally related to fundamental values and preferences. Rather, travel patterns and levels were more likely to result from a combination of *habits* and *circumstances*. Even in cases where values were considered, there seemed to be no clear and consistent link between specific values and specific behaviour. Linkages between values and behaviour emerged through a highly context-specific interaction amongst multiple, and sometimes conflicting values.

A variety of alternative analytical approaches can be applied to understand the complexities of the individual's travel behaviour (Olander and Thøgersen, 1995). One approach, for instance, explained travel behaviour as the convergence of *needs*, *abilities* and *opportunities*. Another approach to understanding travel behaviour involved looking at how individual travel behaviour evolved within a complex web of interactions between individuals, institutions, business and governments. Other approaches included geography-inspired analyses of individuals' time budgets or more traditional engineering or micro-economics-based analyses.

The individual's transport needs evolved in a complex network of different societal influences, cultural preferences and institutional agendas (Stern, 2000). Individual behavioural responses were often constrained by the decisions and actions of other factors, such as the media, the retail sector, industry and governments. It may be more effective to target both these higher-order factors and their messages, since policy measures that focus only on individuals in these networks will most likely fail to bring about substantial shifts in travel behaviour.

3.3.1 (b) A Social Dilemma Analysis of Transport Mode Judgements

Findings from past research on a social dilemma analysis of transport mode judgements were mainly summarized by Rozmi et al. (2013). For example, Van Vugt et al.'s (1996) research findings provided strong evidence that the motivational factors underlying the decision to commute by car or public transport were short travel time and high frequency of public transport. Beirão and Sarsfield Cabral (2007) on the other hand found that the Portuguese particularly searched for advantages of bus travel such as it being cheap, the journey being less stressful, not having to drive, enjoying a comfortable relaxed journey, having an opportunity to read, encountering travel time on bus lanes and less pollution, being able to socialize in the bus, preferably having a seat on the vehicle, experiencing a nice ambience, being free from unpleasant smells, a not too crowded space and having a smooth ride. Their qualitative research concluded that users had a high propensity to use public transport because they felt less driving stress pertaining to not having to drive, allowing them to relax and read a book or newspaper and to socialize in the bus. Beirão and Sarsfield Cabral finally proved that motivations contributing to public transport usage ranged from enjoying better service, being certain that the timetables are followed, having direct transport from home to work, getting information that is readily available, simple and clear, being able to save money, not having or having a parking space, enjoying a comfortable and air-conditioned journey, and contributed to a ride that is total better environment. Smith and Clark (2000) and Ambak et al. (2009) in their research, however, discovered that safety-related issues in choosing public transport as a mode of transport was the guarantee that the following did not occur: pick pocketing, being overcharged, experiencing overcrowding and lack of supervision.

Another example was given by Brons et al. (2009) who highlighted the fact that rail was usually a first choice to the Dutch for long distance travel and for journeys between cities. The last important finding from a study by Popuri et al. (2011) was the advantages of public transport over car in Chicago, USA which consisted of a reliable, stress-free and productive commute. Their study focused on three major public transport services in Chicago: the Chicago Transit Authority

(CTA) buses and trains, the Metra commuter rail service, and the Pace suburban bus service. Public transport was often exploited by travellers in their daily work trips, especially in metropolitan areas mainly owing to these attitudinal factors and that public transport was able to relieve congestion on highways.

3.3.2 Uncertainty about Technology and Behaviour

Technology and behaviour have an interesting relationship. There have been two opinions about technology. Some researchers treat it in a deterministic way, which suggests it a 'technological fix' within problems while some researchers view it as a social construct because its usage is dictated by human beings. In addition to that, technology's function is 'one of enabling, rather than determining behaviour'. For this reason, there exists a sound stochastic, which means uncertainty is naturally found plentiful in the relationships between information and communication technology, ICT and travel behaviour in terms of being unable to predict technology from the aspects of features, costs and friendliness and in terms of not being able to understand and predict behaviour. It is even complex to predict behaviour under circumstances that are not yet familiar to users and potential users (Salomon, 2000).

Relationship of information provision and passengers' travel behaviour was travel information can only change primary travel choice if there was a viable alternative to it (Grotenhuis et al., 2007). Findings of Too and Earl (2010) indicated that commuters rated the availability (easily obtained, correct and updated) of train information as the best trains service quality provided within Varsity Lakes in Gold Coast, Australia.

3.4 TOOLS OF STATISTICAL ANALYSIS AND MODELLING

The Multivariate Statistical Technique of Factor Analysis and the Structural Equation Modeling (SEM) method with Analysis of Moment Structures (AMOS) Graphics and programme (software)

3.4.1 The Exploratory Factor Analysis (EFA)

Factor analysis was identified as a powerful tool to identify suitable dimensions and related items determining the passengers' satisfaction levels on overall rail services. In other words, the objective of the exploratory factor analysis (EFA) was to identify underlying components or structures based on a group of items in a scale, hence reducing the number of variables (or cases) based on relationships represented in a correlation matrix prior to using them in the CFA of the SEM method. Therefore, factor analysis is useful as a data reduction method in addition to data exploration technique. Factor analysis is also done to test the hypotheses formulated regarding the factors determining high service quality attributes. Data is analyzed using the IBM SPSS version 20 computer software.

3.4.2 **The SEM method with** Analysis of Moment Structures **(AMOS) Graphics and programme (software)**

3.4.2 (a) Confirmatory Factor Analysis (CFA)

The SEM method was selected because there was no dependent variable in the questions. This special feature of having no dependent variable had caused the multiple linear regression analysis and the multinomial logistic regression analysis to be rejected or considered less suitable for the statistical modelling method of this research. “Confirmatory Factor Analysis (CFA) *starts* with a hypothesis about the possible structure of a particular area and only then the variables which might fit that structure are carefully selected. The important difference between EFA and CFA is that the former tries to discover (explore) the structures used in the variables, whilst in the latter variables are chosen to confirm a predetermined structure.” (Child, 1990) This provides a method for confirming or testing hypotheses. In other words, the use of factor analysis and EFA are to explore and identify the variables that best define high quality rail service whilst the CFA deliberately determines which of these variables have the greatest impact on rail’s quality of service for a network of routes or corridors. It is in the form of empirical model which is developed from path diagrams. Data (the first and second structural models) are evaluated using the Analysis of Moments Structures (AMOS) software.

According to Zainudin (2012), the structural model can be defined as the link between measurement model for independent construct and measurement model for dependent construct. He further explained that AMOS is one of the softwares developed for analyzing SEM. Other softwares such as LISREL, SEPATH, PRELIS, SIMPLIS, PLS, MPLUS, EQS and SAS will produce simultaneous equations models. However, AMOS is widely employed by researchers for its graphic capabilities. In SEM, there are two models involved. They are the measurement model and the structural model. The researcher needs to analyze the measurement model first before modelling the structural model (Zainudin, 2012).

3.5 OPTIMIZATION MODELS

Mathematical Modelling Procedure and Optimization in Rail Systems Analysis

3.5.1 Introduction

Rail Transport Systems Engineering and Analysis deals with a comprehensive planning, design, analysis and operation of complicated (including the current and future intermodal physical facilities and systems integration (Hull, 2005; Preston, 2012a)) rail systems or service performance, often using expertise in different areas, such as engineers, planners, statisticians, programmers, rail transport modellers and analysts, economists, social service executives, environmental officers, and others. The applications of system analysis involve a structured and systematic scope, procedure, data presentation, critical review of findings, and concluding remarks on the overall observations and results. In view of systems approach, the methodology of field works and data exploratory analysis, modelling and simulation are carefully formulated to examine multiple interactions among the components and processes. With reference to Vuchic (2007), the two major tools often applied in public transport systems analysis are operations research and models. Operations research is a matter of developing mathematical equations or models or expressions to clearly demonstrate and simulate actual systems. The latter tool includes physical, conceptual, analytical, mathematical, and other models. As far as the demand and supply interactions are concerned, the trade-off between economically efficient operation and adequate service for the public is very complex and may require complex analyses and decisions.

3.5.2 Basic Optimization

3.5.2 (a) The What and Why of the Optimization Theory

Benavie (1972) stated that economic theorists have attempted to discover how a complex system responded qualitatively to various exogenous disturbances. For this reason, he explored the theory of optimizing activity. With reference to the Oxford Dictionary of Economics, optimization means the choice from all possible uses of resources of that, which gives the best results (Black, 2003). This is often represented by maximizing an objective function. Critics of optimization argue that there are unlimited numbers of different ways of using given resources. People actually choose between a very limited number of the possibilities, often using crude 'rules of thumb' both to select the possibilities considered and to make choices between them. He further explained the common assumption used for deriving economic models is economic units which are maximizing or minimizing something, be it utility, profits, product, or cost. This statement was supported by Lancaster (1968) who technically translated optimizing as a catch-all term for maximizing, minimizing, or finding a saddle point of the economic analysis. Economic models are further divided into two types, namely, active and passive models. Active economic models are the typical final product of efficient growth. Passive models are generated from general equilibrium studies with the aim to find both the optimum revenue and the optimum policy. The interest is more likely to optimize the behaviour of decision or policy makers. They are often based on the behaviour of individual agents where these agents in specific have well-defined objects of choice. In addition to that, Weintraub (1982) described that agents rationally strove to choose the most preferred object available because they have coherent rankings of those objects. This assumed the characteristics of such models.

This optimization process usually occurs in the presence of constraints, such as income, resources, and production functions. Liu (1980) highlighted that the objectives in control of an economic system include optimization, stabilization, and a combination of the two. He said optimization referred to maximization of at least one payoff, such as profit flow and utility levels of capital assets at the end of the planning stage. Stabilization can be referred to as demand, price, labourers, or capital toward a target level by proper choice of the control (investment, production, or fiscal policy). Lancaster (1968) strongly emphasized that optimization subjected to constraint has been considered by many as defining the essential nature of economics. There must be some fundamental and essential mathematics for analyzing and modelling problems of optimization subjected to constraints.

3.5.2 (b) The Optimization Problems (O.P.)

Intriligator (1971) quoted that problems of optimization are extensive in the modern world because they exist in science, social science, engineering, and even business. However, Mills (1984) pointed out that optimization problems in economic theory and analysis have greatly relied on the improved and modified optimization methods designed by the researchers in the fields of mathematics, economics and telecommunication technology, especially in handling empirical data that leads to very large dimensionality in many models. He specified economic analysis as a term to include both theoretical and practical policy knowledge and studies. Liu (1980) stated that the dynamic feature of economic systems has become increasingly important as the economic systems of modern society have become more complex. He reviewed the concept of state variables, which summarized the history of a system to describe problems in economics while control variables played the role of inter-temporal decision-making. The problem is then analyzed by standard techniques in optimal control, for example, the maximum principle and dynamic programming.

According to Rima (1967), analytical economics as it exists in the present day is amply distinguished by its methodology and objective(s). The respective method is generally deductive from which conclusions are logically deduced. The ultimate objective(s) is always to arrive at theorems or propositions about the economic aspects of man's life which have a significant predictive value. Some problems are unique experiences in manipulating approaches and techniques, most are research-based and real problems, necessitating new solutions and promoting challenges to researchers and professional staff. Fast and recent development and deployment in the optimization theory, especially in mathematical economics, science management or operations research, mathematical programming and control theory, have, therefore, had many applications and have promised an even wider usage in the future.

Here the (O.P.) is demonstrated mathematically based on Weintraub's (1982), Akira (1994) and Winston (2004) theorems, Given an objective function $f : R^n \rightarrow R$, $x \in R^n$ are called instruments. If the set $S \subset R^n$ defines feasible choices, S is called the opportunity set. The general optimization problem is to find an $x \in S$ such that f(x) is as large as possible.

The formal equation is then

(O.P.) max $f(x)$ subject to $x \in S \subset R^n$.

The structure of the analysis is contained in equation (O.P.). The questions of interest are:

Does there exist any solution to the equation (O.P.)?

What conditions on f and S guarantee solutions?

How are solutions found under the specifications of f and S?

Maximizing a real-valued function is the same as minimizing the negative of that function, meaning equation (O.P.) defines a class of minimization problems.

Economists will want to consult the experts' Optimization in Economic Theory for fuller treatment of the ideas presented in the preceding paragraphs.

3.5.3 Introduction to An Economic Optimization Approach

The importance and applicability of mathematical optimization theory to economics theory have its origin in its practicality and creativity in solving and representing problems of economics and operations research. This is referred to as economizing problems by Intriligator (1971). However, the basic and true problems of economics, are that of wisely allocating limited resources among stakeholders in the associated industries. It is because some rational choices and decisions must be made within the resource scarcity. Equally, economics has been associated with the study of making the best use of maximization subject to constraints as explained by Dixit (1990). Here comes the imperative roles for optimization in economic analysis. In the optimization theory, Mills (1984) highlighted that the norm is to choose values for supply and demand quantities (decision variables) so as to optimize or maximize the value targeted by the objective function, for example, the optimal profit. Hillier and Lieberman (1986) add that the objective function is the composite measure of effectiveness (MOE) which is then expressed as a mathematical function of those decision variables. In reality, economic agents usually subject to various unavoidable and risky limitations in deciding upon the optimum resources which are the inputs to the production process. Such limitations in the form of mathematical expressions are often termed constraints.

Dixit (1990) draws attention to an integrated treatment that relates mathematics to the economics from the beginning and thus has the potential to provide quicker and deeper insights. Yet, he emphasized economic intuition rather than mathematical rigour. Rima (1967) supported that economics in its pre-analytic stages did not exist as a separate subject matter, nor were there analytical tools with which researchers and analysts probed into economic matters. Models of optimizing behaviour are used to describe, illustrate or predict the feasible problems. Overall, proofs of the mathematical theorems are formulated to bring out points of economic interest and thus remarkably facilitate economic applications.

The approach just discussed can, of course, be extended to be more complex and realistic models of an economic planning as successfully proven by the extensive works of (Mills, 1984) and (Heal, 1986). Both discussed mixed price-and-command planning where some capital cost, output should be firmly set, the remaining resource-allocation resolutions are subject to the constraints imposed by companies, and are free to attain any profit. More interestingly, the universal use of optimization techniques is to guide and inspire planning decisions in the planning sections and departments of companies' production division, government agencies and so forth. They have historically evolved from linear programming. Mills (1984) stated that linear programming is one of the most widely used planning techniques but it is basically classified under static optimization according to Intriligator (1971).

Traditionally, economists have been concerned primarily with comparative statics analysis which postulates a change in some exogenous factor, for example, an increase in taxation, a discovery of a new oil field, an increase in pay in an industry and studies the 'before-and-after' behavioural change of the relevant economic agents in a static condition. Static mathematical optimization methods are mathematical programming, classical programming, nonlinear programming, and linear programming.

In studies of economic dynamics, more powerful optimizing models are expected because the economic variables must be identified by time. Dynamic optimization is also most needed in studies for policy decisions since they commonly involve multi-period optimal policy models (Lancaster, 1968). Dynamic mathematical optimization methods comprise dynamic programming. The models of historical dynamic optimization tend to be even more complex than those applied in dynamic studies because it is usually necessary to include the specific history of the situation. This historical dynamic is practised by established firms to produce models representing the past and present productive gain.

Undoubtedly, economic optimization approaches are an important analytical tool in many scientific and social science research today. Nevertheless, the proposed models still require rational judgment to positively bring out the benefits. Meaning to say, the greatest difficulty is often found in critically, laterally and creatively arguing in favour against reporting on either some significant problems, errors or findings in modelling the technology. At the end, it is the tasks of familiar decision-makers to first explore the supposed calculations and select what is preferable among the alternatives available.

3.5.4 Economic Mathematical Optimization Approaches

In order to know further about the status of any function of a single variable, $f(x)$ with regard to geometric shape, we may use the convexity test as tabulated in Table 3.1 by determining a second derivative at all possible x. Similarly, functions of multiple variables can also be characterized for their graphical forms as shown in Table 3.2 below. The three partial derivatives must be assessed to satisfy the provisions of a typical curve.

Table 3.1 Convexity test for a single variable function

Second derivative for all possible values of x	Type of curves
$\frac{d^{2}(f)}{dx^{2}} . \leq .0$	*Concave*
$\frac{d^{2}(f)}{dx^{2}} .\langle .0$	*Strictly concave*
$\frac{d^{2}(f)}{dx^{2}} . \geq .0$	*Convex*
$\frac{d^{2}(f)}{dx^{2}} .\rangle .0$	*Strictly convex*

Source: Hillier and Lieberman (1995)

Table 3.2 Convexity test for a multiple variable function

Second derivatives or Partial derivatives for values of (x_1, x_2)	*Concave*	*Strictly concave*	*Convex*	*Strictly convex*
	All possible values of x			
$\frac{\partial^{2} f(x_1, x_2)}{\partial x_1^{2}} \frac{\partial^{2} f(x_1, x_2)}{\partial x_2^{2}} - \left[\frac{\partial^{2} f(x_1, x_2)}{\partial x_1 . \partial x_2}\right]^{2}$	$\geq .0$	$\rangle .0$	$\geq .0$	$\rangle .0$
$\frac{\partial^{2} f(x_1, x_2)}{\partial x_1^{2}}$	$\leq .0$	$\langle .0$	$\geq .0$	$\rangle .0$
$\frac{\partial^{2} f(x_1, x_2)}{\partial x_2^{2}}$	$\leq .0$	$\langle .0$	$\geq .0$	$\rangle .0$

Source: Hillier and Lieberman (1995)

The classical methods of calculus (classical optimization methods) is used for finding a solution (when $x = x^*$) that maximizes or minimizes a function subject to equality constraints on the values of these variables. The functions are continuously analyzed for their first, second and partial derivatives' results to mathematically confirm the geometric properties of the critical points (refer to Tables 3.1 and 3.2).

3.6 DETERMINATION OF THE OPTIMAL HEADWAY

3.6.1 Determination of the Optimal Headway

A simple worked example of model development and application in rail transport systems operations have adopted the basic model derived from the work of Vickrey (1955), Mohring (1972), Jansson (1980), Nash (1988) and Vuchic (2005, 2007).

3.6.1 (a) Simplest Formulation

Consider a simple rail line where the operator cost is a function of hourly cost of vehicle operation, c_o and that the user cost consists of in-vehicle time, walk time and wait time. Assume rail operating speed is fixed and we know that the rail route network is fixed, so that in-vehicle time and walk time are constant. However, the optimal headway on a rail line, h^* is simply and intuitively derived from the trade-off between the train operator's operating cost, C_O, which depends on the number of vehicle (transit units, TUs) on the line, N and users' costs, C_P in terms of average passenger waiting time which is assumed to be one-half of the headway i.e., $\frac{h}{2}$. Assume that there are frequent services, the stops are evenly spaced and the respective train travel time between stations is constant. Passengers arrive at stops at random and are uniformly distributed. Assume also there are no significant externalities to be considered, the total social cost, *TSC* can be expressed as the sum of operator and user costs,

$$TSC = C_O + C_P = N.c_O + P_L \frac{h}{2.60} c_p \qquad (3.1)$$

(**waiting cost**)

where,

c_o = hourly cost of TU operation, that is driver and vehicle costs ($/(TU-h);

c_p = hourly cost of passenger waiting time ($/(passenger-h);

P_L = the number of passengers per hour travelling on the line (passenger/h);

h = headway (minutes) = $\frac{60 \alpha_{\max} C_{TU}}{P_{\max}}$;

T = cycle time (minutes) = the total round trip time on a line = $\frac{120 L}{v_c}$;

N = Fleet size or the total number of vehicles needed for operation of a line, or of an entire network (TU);

$P_{\max}$ = maximum passenger volume (usually on Maximum Load Section (MLS));

MLS = maximum load section is a station spacing with maximum passenger volume that determines required line capacity (-);

the TU (bus or train) capacity, C_{TU} (spaces/TU) = *n* X C_{υ};

load factor, α_{max} (passengers/space);

length, L (km);

Cycle speed, v_c (km/h) on the line;

C_P = total user or passenger cost per hour ($/h);

C_O = total operator cost per hour ($/h); and

TSC = total social cost ($/h).

$$TSC = \frac{T}{h} c_O + \frac{P_L}{120} h \cdot c_p$$

To find the optimal headway, *h**, we minimize *TSC* by differentiating it with respect to *h* and set equal to zero,

$$\frac{\partial TSC}{\partial h} = -\frac{T}{h^2} c_O + \frac{P_L}{120} c_p = 0$$

*h** could be obtained from the *TSC* equation mathematically by deriving from its second order (i.e., the second derivative) and checking the results to be greater than zero.

$$\frac{\partial^2 TSC}{\partial h^2} = \frac{2T.c_O}{h^3}$$ (> 0 Minimum value is confirmed)

Rearranging the results of the first derivative, will provide solutions for *h**,

$$\frac{T \cdot c_O}{h^2} = \frac{P_L}{120} c_p$$

$$h^2 \cdot P_L \cdot c_p = 120. T \cdot c_O$$

$$h^2 = \frac{120. T \cdot c_O}{P_L \cdot c_p}$$

$$h^* = \sqrt{\frac{120. T \cdot c_O}{P_L \cdot c_p}}$$

(3.2)

The above square root principle states that the optimal headway should increase in proportion to the square root of the cycle time, T, while it decreases as user demand increases. The optimal headway is also proportionally related to the square root of other parameters, as well. If cycle time doubles, headway should increase by √2 = (1.414 – 1.000)/1.000 X 100% = 41.4%. The optimal headway should increase with vehicle operating cost and decrease with increased value of passenger time.

Compute optimal fleet size, N* for the minimum total cost headway by substituting the above *h** with (T/N) (as by definition $h = \frac{T}{N}$),

$$\left(\frac{T}{N}\right)^2 = \left(\sqrt{\frac{120.T.c_o}{P_L \cdot c_p}}\right)^2$$

$$\frac{T^2}{N^2} = \frac{120.T.c_o}{P_L \cdot c_p}$$

$$N^2 = \frac{P_L \cdot c_p \cdot T^2}{120.T.c_o}$$

$$\because N^* = \sqrt{\frac{P_L.T.c_p}{120.c_o}}$$

(3.3)

The total social costs that were negatively impacted by the *KTM Komuter* in the KL Inbound and KL Outbound of Port Klang-Sentul corridor are shown below. The total social cost was around RM15,000.00 per hour for both directions in 2010. The total user cost was more than RM650.00 per hour for morning peak because of higher average maximum passenger per hour i.e. 97 passengers per hour. For KL Outbound, the total user cost was more than RM850.00 per hour for evening peak because of average maximum passenger per hour was very high i.e. 126 passengers per hour.

KL Inbound						
Time Variations	User or Passenger Cost per hour (RM/h)	Average Maximum Passenger per hour	Mean Time Travelled per passenger(h/passenger)	Total User Costs (RM/h) 2010	Total Operator Costs	Total Social Costs
Early Bird	3.56	86	1.925	589.36	14,555	15,144.36
Morning Peak		97		664.74		15,219.74
Late Comer		70		479.71		15,034.71
Afternoon Peak		67		459.15		15,014.15
Early Release		62		424.89		14,979.89
Evening Peak		72		493.42		15,048.42
Off Peak		31		212.44		14,767.44

Source: KTMB (2012)

KL Outbound						
Time Variations	User or Passenger Cost per hour (RM/h)	Average Maximum Passenger per hour	Mean Time Travelled per passenger(h/passenger)	Total User Costs (RM/h) 2010	Total Operator Costs	Total Social Costs
Early Bird	3.56	39	1.925	267.27	14,555	14,822.27
Morning Peak		66		452.30		15,007.30
Late Comer		53		363.21		14,918.21
Afternoon Peak		57		390.62		14,945.62
Early Release		79		541.39		15,096.39
Evening Peak		126		863.48		15,418.48
Off Peak		58		397.47		14,952.47

Source: KTMB (2012)

3.6.2 Determination of the Optimal Vehicle Type or TU Capacity

More simplified assumptions for the simple model of a rail line:-

Passenger demand, $P_{\max}$ (design hour volume, DHV or design passenger volume, P_d) is constant and is related to the total number of passengers boarding along the entire line, P_B, by a coefficient: $P_{\max} = \eta_p P_B$; here, P_B also represents P_L.

Cycle speed, v_c on the line is independent of TU size and of the number of passengers;

$$P_d = P_{\max} \; PHC \; ;$$

N_{TU} = number of TUs, $\frac{N}{n}$ (TU);

Selection of the size (number) of TUs or type of public transport vehicle on the line will be expressed by the given line parameters. Here,

$$h \quad = \quad \text{headway (minutes)} \quad = \quad \frac{60\alpha_{\max} C_{TU}}{P_{\max}};$$

$$T \quad = \quad \text{cycle time (minutes)} \quad = \quad \frac{120L}{v_c};$$

$$N_{TU} = \frac{T}{h} = \frac{120L}{h\,v_c} = \frac{2L\;P_{\max}}{\alpha_{\max} C_{TU} v_c} = \frac{2L\;P_d(1+\gamma)}{\alpha n\;C_v v_c};$$

A trade-off between the two parties given is that there is a maximum passenger rail demand, $P_{\max}$, the operator supplies an adequate number of TU (large size) because of lower fleet of rail vehicle operating cost per unit capacity and passengers demand for higher service frequency (lower headways), higher TU of smaller dimension.

$$TSC = \frac{T}{h} c_O + \frac{P_L}{120} h \cdot c_p$$

$$TSC = \frac{2L\ P_{\max}}{\alpha_{\max} C_{TU} v_c} c_O + \frac{P_L \alpha_{\max} C_{TU}}{2P_{\max}} c_p$$

To find the optimal value of the vehicle capacity, C^*_{TU}, we minimize *TSC* by differentiating it with respect to C_{TU} and set equal to zero,

$$\frac{\partial TSC}{\partial C_{TU}} = \frac{\partial}{\partial C_{TU}} \left[\frac{2L\ P_{\max}}{\alpha_{\max} C_{TU} v_c} c_O + \frac{P_L \alpha_{\max} X\ C_{TU}}{2P_{\max}} c_p \right] = 0$$

$$\frac{\partial TSC}{\partial C_{TU}} = - \frac{2L\ P_{\max}}{\alpha_{\max} C^2_{TU} v_c} c_O + \frac{P_L \alpha_{\max}}{2P_{\max}} c_p = 0$$

To verify that C^*_{TU} could be obtained from the *TSC* equation mathematically, derive from its second order (i.e., the second derivative) and check the result to be greater than zero.

$$\frac{\partial^2 TSC}{\partial C^2_{TU}} = \frac{4L.P_{\max} c_O}{\alpha_{\max} C^3_{TU} v_c} \quad \text{(> 0 Minimum value is confirmed)}$$

Rearranging the results of the first derivative, solving the optimum TU capacity (C_{TU}^{*}) results in the minimum total cost,

$$\frac{2L\ P_{\max}}{\alpha_{\max} C_{TU}^{2} v_c}\ c_O = \frac{P_L \alpha_{\max}}{2P_{\max}}\ c_p$$

$$C_{TU}^{2}\ \alpha_{\max}^{2}\ v_c\ P_L\ c_p = 4\ L\ P_{\max}^{2}\ c_O$$

$$C_{TU}^{2} = \frac{4L\,P_{\max}^{2} c_o}{\alpha_{\max}^{2} v_c P_L c_p}$$

$$C_{TU}^{*} = \sqrt{\frac{4L\,P_{\max}^{2} c_o}{\alpha_{\max}^{2} v_c P_L c_p}} = \frac{2\,P_{\max}}{\alpha_{\max}} \sqrt{\frac{L\,c_o}{v_c P_L c_p}}$$

where,

$$P_{\max} = \eta_p\, P_L;$$

$$C_{TU}^{*} = \frac{2\eta_p}{\alpha_{\max}} \sqrt{\frac{P_L^{2} L\,c_o}{v_c P_L c_p}}$$

$$C_{TU}^{*} = \frac{2\eta_p}{\alpha_{\max}} \sqrt{\frac{P_L L\,c_o}{v_c c_p}}$$

(3.4)

However, passenger demand is constant only for a certain period. It is more pragmatic to consider different TU capacities for different times. For example, the vehicle selected for use within peak hour will definitely be sub-optimal for off-peak, and vice versa. Thus, the determination of optimum TU capacity should take into consideration time variations. During off-peak periods, the cost-effective service volume is governed by the service headway rather than passenger volumes, not exceeding the line capacity that is governed by the policy headway. The vehicle capacity for off-peak operations could be determined straightaway from the standard diagram for the selection of the optimal combination of TU size, service frequency or headway and load factor for different scheduling periods.

The mathematical relationship of the objective function for the main decision variables can be described using square root functions. The relationship between this equation and the previous ones are significant.

Try to calculate the marginal social cost, *MSC*:

$$MSC = \frac{\partial TSC}{\partial P} = \frac{\partial\left(\frac{T}{h}\cdot c_o \cdot + \cdot \frac{P_L . h . c_p}{120}\right).}{\partial P}$$

$$MSC = \frac{h \cdot c_p}{120}$$

$$MSC = \frac{\partial\left(c_1 M + \frac{c_2}{L} mP + \frac{60 v_1}{2M} RNP + \frac{0.5 v_1}{N} WP + v_2 t_1 P + \frac{v_2}{M} t_2 P^2 m\right)}{\partial P}$$

$$MSC = \left(\frac{c_2}{L} m + \frac{30 v_1}{M} RN + \frac{0.5 v_1}{N} W + v_2 t_1 + \frac{2 v_2}{M} t_2 Pm \right)$$

The average social cost, *ASC* can be calculated as follows:

$$ASC = \frac{TSC}{P};$$

$$ASC = \frac{T \cdot c_o}{h \cdot P} + \frac{h \cdot c_p}{120};$$

where,

$$N_{TU} = \frac{T \cdot}{h \cdot};$$

$$ASC = \frac{T \cdot c_o}{h \cdot P} + \frac{T \cdot c_p}{120 \cdot N_{TU}}$$

$$ASC = \left(AOC \cdot + \cdot AUC \right)$$

$$ASC = \left(\frac{c_1}{P} M + \frac{c_2}{L} m + \frac{30 v_1}{M} RN + \frac{0.5 v_1}{N} W + v_2 t_1 + \frac{v_2}{M} t_2 Pm \right)$$

where,

AOC = Average Operator Cost

AUC = Average User Cost

2a) With wait time **half** the headway

$$TSC = C_O + C_P = N.c_o + P_L \frac{h}{2.60} c_p$$

$$\frac{\partial TSC}{\partial N} = c_o. - \frac{P_L.T.c_p}{2.60.N^2} = 0$$

$$c_o = \frac{P_L.T.c_p}{2.60.N^2},$$

$$\because AOC = c_o \cdot N = \frac{P_L.T.c_p}{2.60.N}$$

2b) With wait time a **quarter** the headway

$$\frac{\partial TSC}{\partial N} = c_o. - \frac{P_L.T.c_p}{4.60.N^2} = 0;$$

$$c_o = \frac{P_L.T.c_p}{4.60.N^2};$$

$$\because AOC = c_o \cdot N = \frac{P_L.T.c_p}{4.60.N};$$

$$AUC = \frac{TUC}{P} = \frac{P_L.T.c_p}{2.60.N}\left(\frac{1}{P_L}\right)$$

where,

$P = P_L$ = passenger trips per hour;

$$\because AUC = \frac{T.c_p}{120.N}$$

The optimal price, $P^* = \left(MSC - AUC\right)$ (Nash, 1988)

$$P^* =$$

$$\left(\frac{c_2}{L}m + \frac{30v_1}{M}RN + \frac{0.5v_1}{N}W + v_2t_1 + \frac{2v_2}{M}t_2Pm - \frac{30v_1}{M}RN - \frac{0.5v_1}{N}W - v_2t_1 - \frac{v_2}{M}t_2Pm\right)$$

$$P^* = \left(\frac{c_2m}{L} + \frac{v_2t_2}{M}Pm\right)$$

$$P^* = m\left(\frac{c_2}{L} + \frac{v_2}{M}t_2P\right)$$

(3.5)

where,

m = means passenger trip length;

L = maximum load factor;

c_2 = operating cost per passenger kilometre;

v_2 = value of in-vehicle time (cents per minute);

t_2 = mean boarding time per passenger (minute per passenger);

P = passenger trips per hour; and

M = train kilometres per route per hour.

Therefore, the optimal price comprises three parts: boarding cost, crowding cost and the operator's marginal cost (Jansson, 1993). With crowding cost indicated in Equation 3.5, this seems to contradict the relevant economic theory, that is, the price is always said to be an optimum when the marginal costs are subjected to larger vehicle size and boarding delays in the means of carrying more passengers. On the other hand, it means that the realistic optimum price should consider the real effect of overcrowding on the existing and/or additional rail cars and that the respective marginal social costs will still be lower than or equal to the average operator costs and would require no more subsidies.

3.6.3 Formulation of Rail Model with Effect of Negative Externalities

Consider a simple rail line where operator cost is a function of hourly cost of vehicle operation, c_o and user cost consists of in-vehicle time, walk time and wait time. Assume rail operating speed is fixed and we know that the rail route network is fixed, so that in-vehicle time and walk time are constant. But, the optimal headway on a rail line, h^* is simply and intuitively derived from the trade-off between the train operator's operating cost, C_O, which depends on the number of vehicles (transit units, TUs) on the line, N and users' costs, C_P in terms of average passenger waiting time which is assumed to be one-half of the headway i.e., $\frac{h}{2}$.

Assume frequent services and the stops are evenly spaced, passengers arrive at stops at random and are uniformly distributed. Assume there are also significant externalities to be considered, the total social cost, *TSC* can be expressed as the sum of operator costs, user costs, and external costs.

$$TSC = C_O + C_P + C_e = N.c_O + P_L \frac{h}{2.60} c_p + E_r\, c_e$$

(**waiting cost**) (**rail external costs**)

(3.6)

$$TSC = C_O + C_P + C_e = N.c_O + P_L \frac{h}{2.60} c_p$$

$$+ \{D_V V + D_F V + D_{LS} V + C_D V + TS\ Q + A_C Q\}$$

E_r = Vehicle and Passenger Occupancies based on distance travelled (TU km, vehicle kms, passengers kms);

c_e = hourly cost of TU operation or passenger flow [$/(TU km-h), $/(passengers km-h)];

$D_V V$ = rail damage* costs due to vandalism per vehicle km;

$D_F V$ = rail damage* costs due to flood per vehicle km;

$D_{LS} V$ = rail damage* costs due to landslide of the backfill of the railway track per vehicle kms;

$C_D V$ = external delay costs due to delay propagation at stops and stations on a rail line per vehicle kms;

External delay showing negative production externalities i.e. an external cost, such as the cost of delay propagation at stops and stations on a rail line, makes the marginal social cost (MSC) curve higher than the private marginal cost (MPC).

$TS\ Q$ = transhipment* costs per passenger kms; and

$A_C Q =$ accident costs per passenger kms.

*According to a website (http://en.wikibooks.org accessed on 20th. October 2013), a consensus definition might be, “Externalities are costs (external disbenefits) or external benefits generated by a system (in this case transportation, including infrastructure and vehicle/carrier operations) and borne in part or in whole by parties outside the system."

V = vehicle kms; and

Q = passenger kms.

Note:- Rail's Negative External Costs

Real examples of the negative externalities are rail damage and repair due to flood, landslide of the backfill, vandalism; transhipment costs; external delay costs due to delay propagation on a rail line; and rail accidents. There is no such external costs-related as carbon emissions, air quality, noise and vibration since there is no field measurement undertaken by the *KTMB* over the past operation periods. Transhipment costs are defined as costs involved when shifting stranded passengers in the train coaches at the railway track/route during natural disasters and transporting them to the nearest *KTM Komuter* station. Examples of natural disasters that have occurred at the railway tracks/routes include floods and land slides.

(Sources: KTMB (2009, 2012, 2015), Grant and Bamford (2006), Bickel and Friedrich (2001), and Button (1993))

Microsoft Excel software can be used to calculate the total social and environmental costs negatively impacted by the *KTM Komuter* in the Port Klang-Sentul corridor as follows:

Total Operator Cost per hour (RM/h)	Total User or Passenger Cost per hour (RM/h)	Total Negative Externalities Cost (RM/h)	Total Social Costs (TSC) (RM/h)				
			2008	2009	2010	2011	2012
14,579.00	3.56	844.75	15,427.31				
13,767.00	3.56	85.53		13,856.09			
14,555.00	3.56	483.27			15,041.83		
12,871.00	3.56	1,661.98				14,536.54	
19,831.00	3.56	856.39					20,690.95

Source: KTMB (2012)

As a corollary, 2012 recorded the highest total social costs of RM20,690.95 per hour as the effect of the total negative externalities costs of RM856.39 and the total operator cost per hour was the highest compared to the other years. Despite the lowest total negative externalities cost per hour in 2009, the respective total social costs were also found to be the lowest compared to the other years.

3.7 PROPOSED APPROACH – COMBINED FACTOR ANALYSIS AND OPTIMIZATION

Modelling and Analysis will use the combined factor analysis and economic optimisation approach. Based on Table 8.5 (Results of Convergent Validity Test) and the KOMIQUAL models which are the results of factor analysis, the focus of the economic optimisation should be on improving the train's LOS and overall service quality with respect to service frequency and schedules, people (soft) services or skills and space-comfort. Parking facilities also have a notable positive effect. So, the next research interest is to gauge optimal headway, optimal fleet size, optimal TU capacity and optimal pricing in the aspect of economic optimisation in order to investigate their significant impacts on train service frequency/schedules/reliability, parking facilities, people services and space-comfort. In short, the output of factor analysis provides a guide prior to conducting the economic optimisation steps using the classic Calculus method and Microsoft Excel software. The relationship is shown in Figure 3.1.

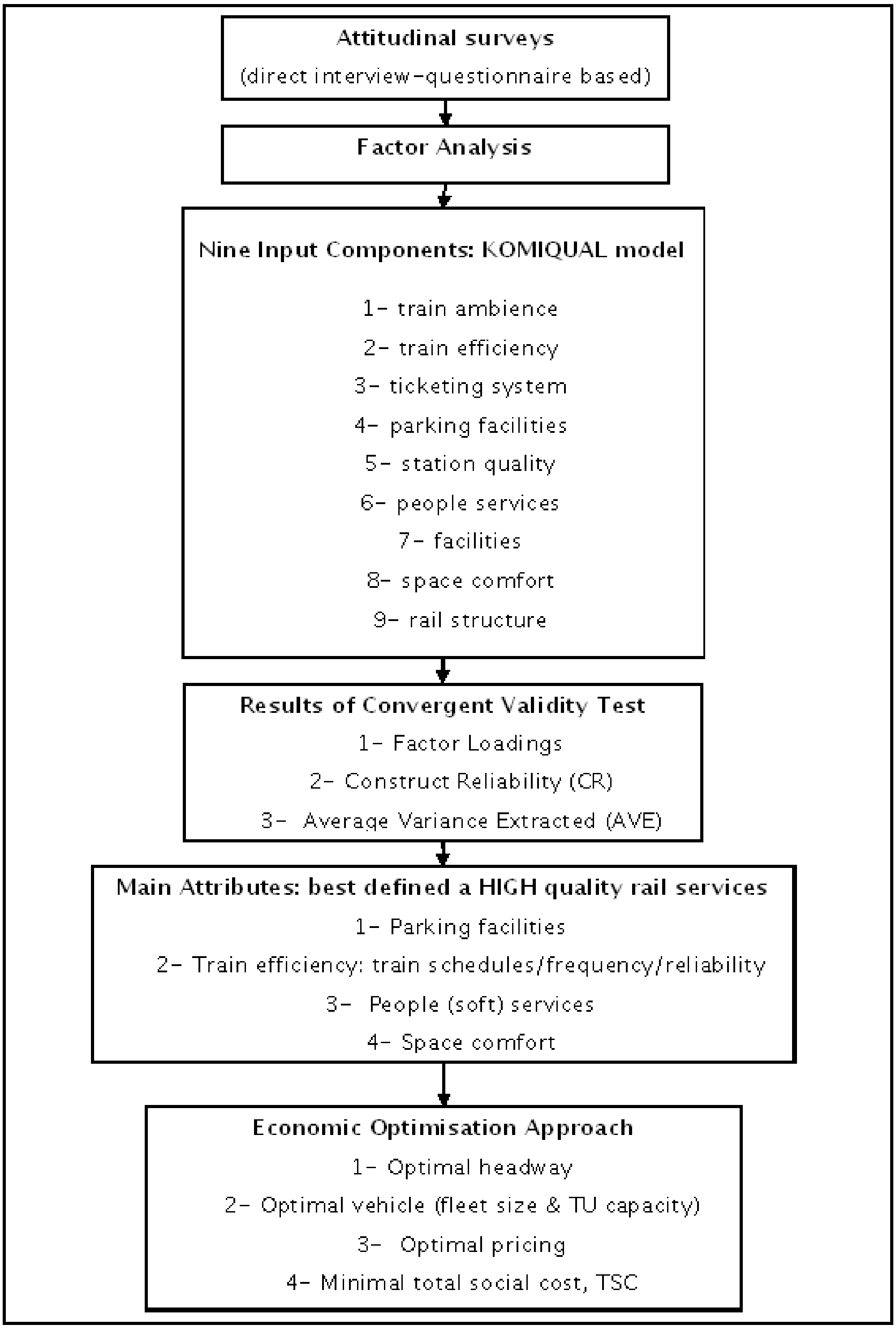

Figure 3.1 Framework of a Proposed Approach: Combined Factor Analysis and Economic Optimisation for *KTM Komuter* service

3.8 CONCLUSIONS

A systematic methodological review of theoretical knowledge and literature has assisted in the further development and refinement of both the problem statements and the hypotheses. Attributes price and travel time were derived from an economic theory. Further research on Attitudinal models and Optimisation models need to be undertaken before an association between Combined Factor Analysis and Optimisation is clearly understood.

CHAPTER 4 : PUBLIC TRANSPORT IN KL

This chapter provides an overview on the historical and modern development of Kuala Lumpur with regard to urbanization, economic development and industrialization, motorization, the role of urban public transport and decline in public transport, problems encountered when utilising personal/private transport (car), namely, congestion, safety and its impact on the environment. This is followed by introducing the potential usage of rail public transport, its historical background and the development of rail network in Kuala Lumpur and its conurbation (KLC). This chapter specifically contains available literature associated with the major topics covered.

4.1 INTRODUCTION

Apart from private transport, public transport continues to play a major role in the development of urban life especially so in KL. The Malaysia Government provides public transport to the general public to ease mobility and to create greater accessibility from one place to another. Public transport in KL also enables medium to low income wage earners without access to private vehicles and people who do not want to drive private vehicles to satisfy personal social and economic needs. However, the changes in lifestyles and patterns of land uses along with high car usage and poor public transport planning, lack of integration and coordination in general have apparently reduced the efficacy of public transport.

4.2 INTRODUCTION TO THE GEOGRAPHICAL CORE REGION OF KUALA LUMPUR

Kuala Lumpur is commonly known as KL. KL lies in the central western region of Peninsular Malaysia. At the same time, KL lies just north of the equator. Therefore, it has a constant rate of high temperatures and heavy rainfall because of high humidity. The average annual temperature is 27° C (80° F). The average rainfall is 2,370 mm a year. KL is also located in the heart of South East Asia (Figure 4.1).

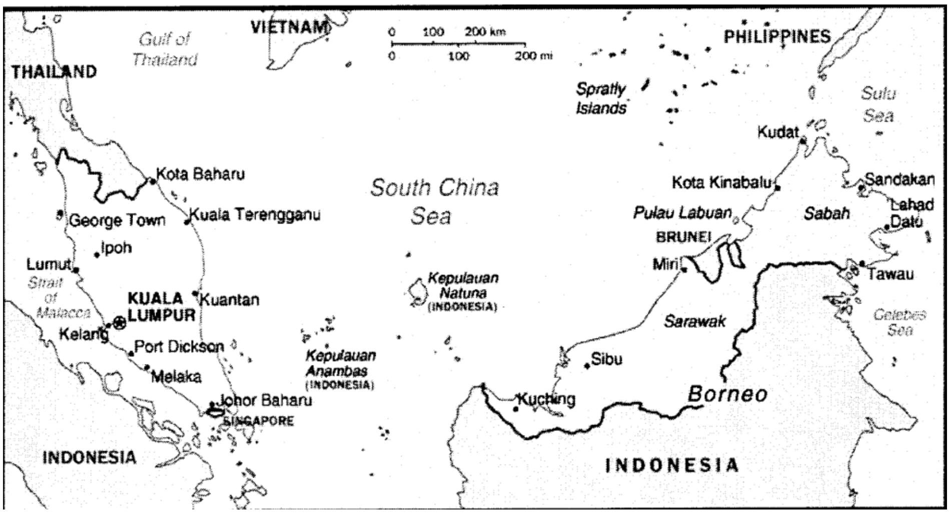

Figure 4.1 Location of Kuala Lumpur

<u>Source: Yap (2004)</u>

For more than fifty years, KL has been the capital city of Malaysia. KL was awarded a city status on February <u>1, 1972</u>. It became the <u>Federal Territory</u> of Malaysia on February 1, <u>1974</u>. The KL city centre (17.8 km^2) was once home to the executive and judicial branches of the federal government. The prime city of KL is also the Kuala Lumpur Core Urban Region (KLCUR) (Figure 4.2). The KLCUR includes the inner core (36.3 km^2), the Federal Territory of Kuala Lumpur (FTKL), and the state of Selangor (Vining, 1985, Zulina, 2003, Lee, 2009). The FTKL covers an area of 243 km^2 (Kuala Lumpur City Hall, 2005). Selangor comprises the primary diffusion corridor and the outer periphery areas out of its land area of 7,930 km^2. The primary diffusion corridor also known as urban agglomeration consists of Port Klang, the Royal capital of Klang, Shah Alam, Subang Jaya and Petaling Jaya. The outer periphery areas include districts such as Sabak Bernam, Ulu Selangor, Kuala Selangor, Gombak, the outer periphery areas of Klang and Petaling districts, Ulu Langat, Kuala Langat, and Sepang. Sepang constitutes several 'smart centres', namely, the Federal Territory of Putrajaya (49.0 km^2) and Cyberjaya (28.94 km^2).

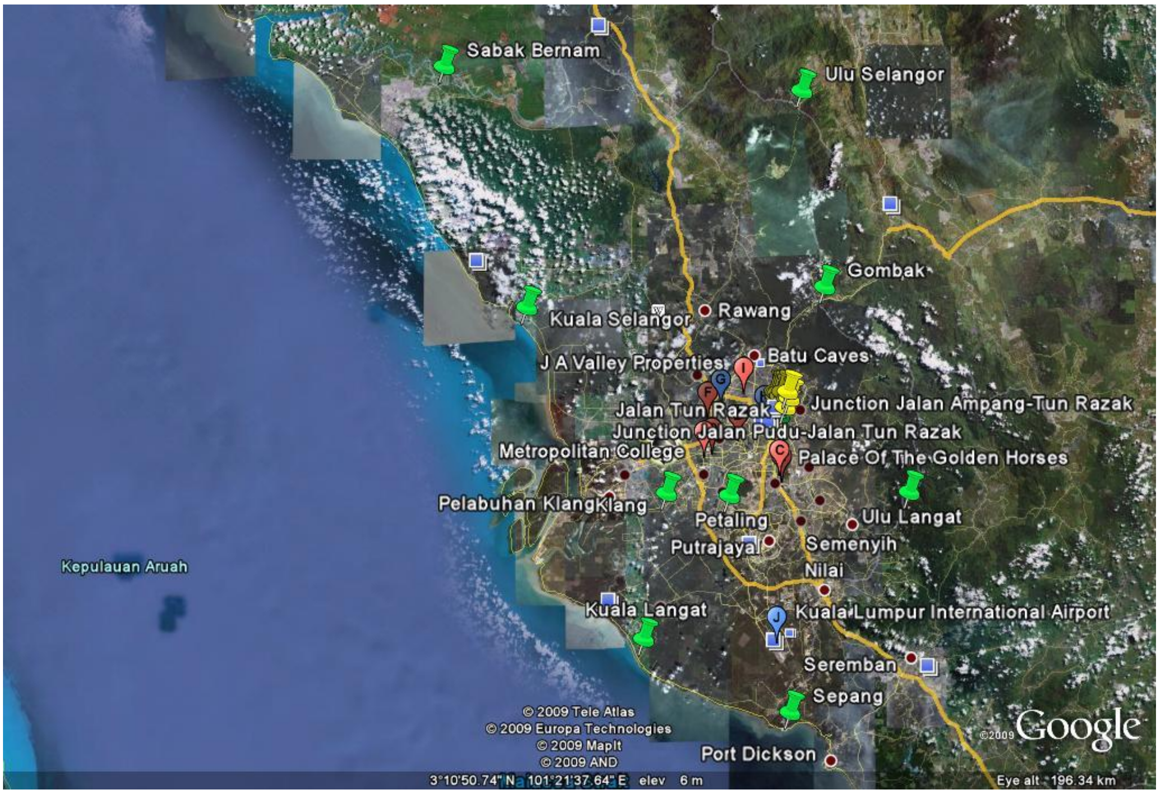

Figure 4.2 Placemarks (Green) indicate borders of KLCUR
= Inner Core + FTKL + Districts of Selangor

Within KLCUR (Green - 8,200 km^2 in Figure 4.2) is the Kuala Lumpur Metropolitan Area (KLMA), (Figures 4.3 and 4.4). The KLMA constitutes the

Greater Kuala Lumpur and the Multimedia Super Corridor (MSC). The KLMA covers the city centre of KL and its suburbs. Hence, KLMA is also called KL and its conurbation. Immense urban sprawl has prompted the KLMA to cover an area of nearly 4,000 km^2 from Bukit Jalil (south FTKL) to KLIA (south Sepang) (Bunnell et al., 2002, Barter, 2004, Lee, 2005). The Greater Kuala Lumpur is also known as Klang Valley (Klang Valley Planning Unit, 1988 cited in (Jamilah, 1997)). Klang Valley with the initial area of 2,843 km^2 encompasses five districts such as FTKL, Petaling, Klang, Gombak and Ulu Langat (Jamilah et al., 2001, mtransgroup, 2003) situating in the middle of Peninsular (Chuen et al., 2014) (Figure 4.3). The MSC includes the Greenfield Corridor and an Airport city which covers an area which is 50 km long and 15 km wide (mtransgroup, 2003, Zulina, 2003). However, the Kuala Lumpur Metropolitan Region (KLMR) encompasses Klang Valley and southern districts like Kuala Langat and Sepang as depicted in Figure 4.3 (Jamilah et al., 2001).

KL was also declared as one of the mega-urban regions (MURs) because of its size which has doubled in less than 15 years. Hence, it was labelled KL MUR (Douglass, 2000). MURs are characterized by an extended metropolitan region with complete urban transport networks. The KL MUR covers the Klang Valley within an area of 3,200 km^2.

4.3 URBANIZATION

Urban migrations occurred as early as the late 1940s. This referred to contemporary urbanization during that period which provided ample job opportunities in the commercial and trading activities (Hamzah, 1966). KL is the best example of a city which has managed to preserve its cultural heritage: blending modern conveniences and safety to offer urbanization to every urbanite. Therefore, Malaysian governments have undertaken various urban development projects in recent years (Figures 4.5 and 4.6). From Figure 4.5, it can be noted that the next three decades following the 1970s saw the rapid urban development of KLMA. Its population was less than a million (Figure 4.6). Before the 1980s, the trend of growth skewed (Alden and Awang, 1985, Lee, 2005), but the trend changed and there was great increase in the early 1980s (Zulina, 2003) of which some 40% of its population was under fifteen years of age according to Alden and Awang (1985). However, the average population of Klang Valley under 15 was about 30% in 1991 and 2000 as can be seen from Figure 4.10. Figure 4.9 displays an intriguing fact that both the distribution of males and females in the state of Selangor and Klang Valley increased uniformly in 1991 and 2000. Figure 4.10 also shows that more than two-thirds of the population in the Golden Triangle, FTKL, Selangor and Klang Valley was below 65 years in 1991 and 2000.

The population of FTKL rapidly decreased from 2.15 million in 1991 to 1.40 million in 2000 (Figures 4.6 and 4.7). The 1.40 million figure highlights only about a third of the total population of the KLMA, i.e., 4.3 million people (Zulina, 2003). This figure denotes KLMA presenting one-fifth of the percentage share of the national population i.e., 20.1 million in 1997 (Douglass, 2000). Selangor's population was around 4.2 million in 2000. The FTKL recorded the highest population density and residential density in 2000 i.e., 5676 persons per square km (Zulina, 2003) and 5,800 persons per square km (mtransgroup, 2003), respectively.

In Selangor the population density was far lower than that of the FTKL with 526 persons per square km (Zulina, 2003).

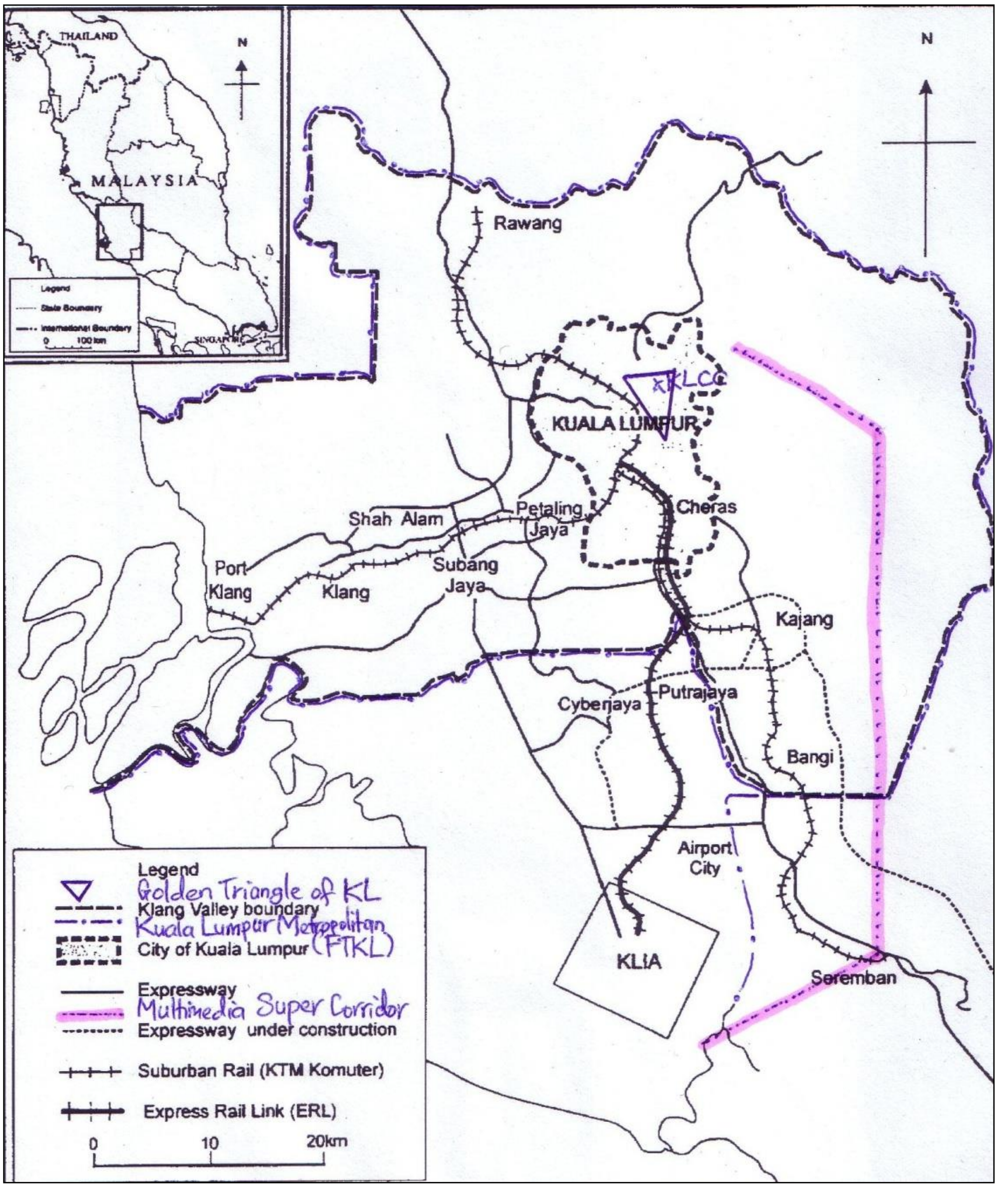

Figure 4.3 Kuala Lumpur Metropolitan Area*the above City of Kuala Lumpur is also referred to as FTKL.

Source: Bunnell et al. (2002)

Figure 4.4 Kuala Lumpur Metropolitan Region within the State of Selangor

Source: Jamilah et al. (2001)

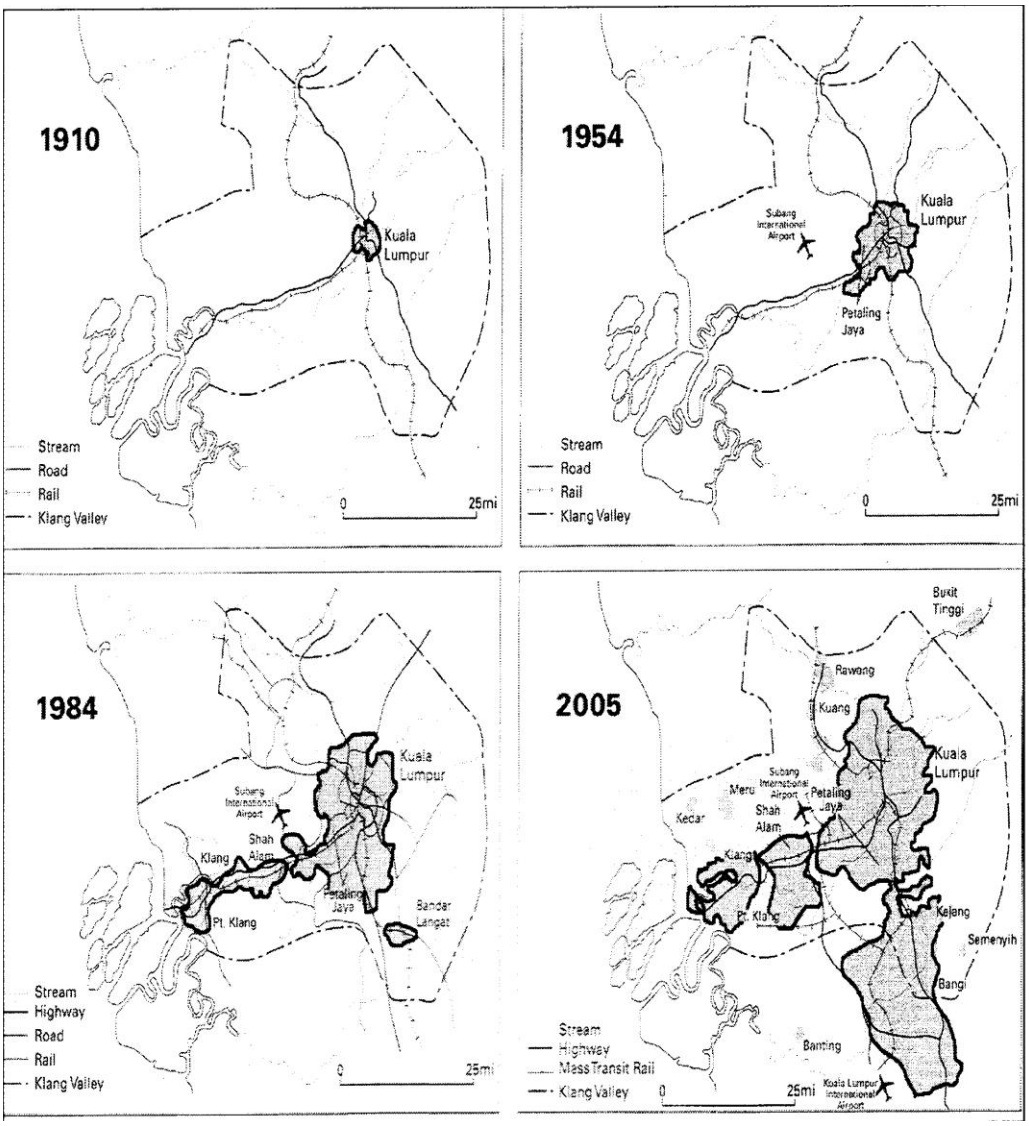

Figure 4.5 Urban Growth in the Klang Valley from 1910 to 2005

Source: Airess (2000) as cited by Yap (2004)

The average annual growth rate of urban population of the FTKL only increased from 2.0% during the Seventh Malaysia Plan (1996-2000) to 2.2% during the Eighth Malaysia Plan (2001-2005) compared to the growth rate of urban population in Selangor, that is, from 7.3 to 5.0% during the same period. The data from Selangor encompassed the Federal Territory of Putrajaya. The corresponding rates of urbanization were 100% from 1995 to 2000, and from 2001 to 2005, the rates of urbanization rose from 80.8 to 88.3%, reaching 92.7%. Between 1996 and 2005, the rate of urban population growth was the highest in Selangor. Both the population density and the residential density of the FTKL were very much higher than that of Selangor, i.e., about eleven times. These facts and figures indicated that active migrations took place from FTKL to all areas around it in the late 1980s (Figures 4.7 through 4.10 and 4.11) due to higher land prices in the city centre (Norlida et al., 2006; Hossain, 2007), spectacular rise of new towns, cities, housing areas, industrial zones (Jamilah et al., 2001) and the relocation of some government administrative agencies. As such, the FTKL surroundings involving a new concentration of population density were considered as part of Selangor from which they became part of both the Klang Valley and KLMA. From Figure 4.9, it is visible that the distribution of genders - both males and females increased at about the same number, i.e., more than one million in Selangor for 1991 while the population of both the male and female population increased approximately to two million in Selangor in 2000. A similar parallel pattern can be seen in the population growth of the Klang Valley in 1991 and 2000. This is not surprising because Selangor fosters many potential developing areas out of its total land area of 7,960 square km regardless of the major industrial zone it covered. Selangor is roughly thirty three times larger than FTKL in term of size. These trends of decentralization kept occurring because of the extension of built-up areas that formed periodically in the KLCUR.

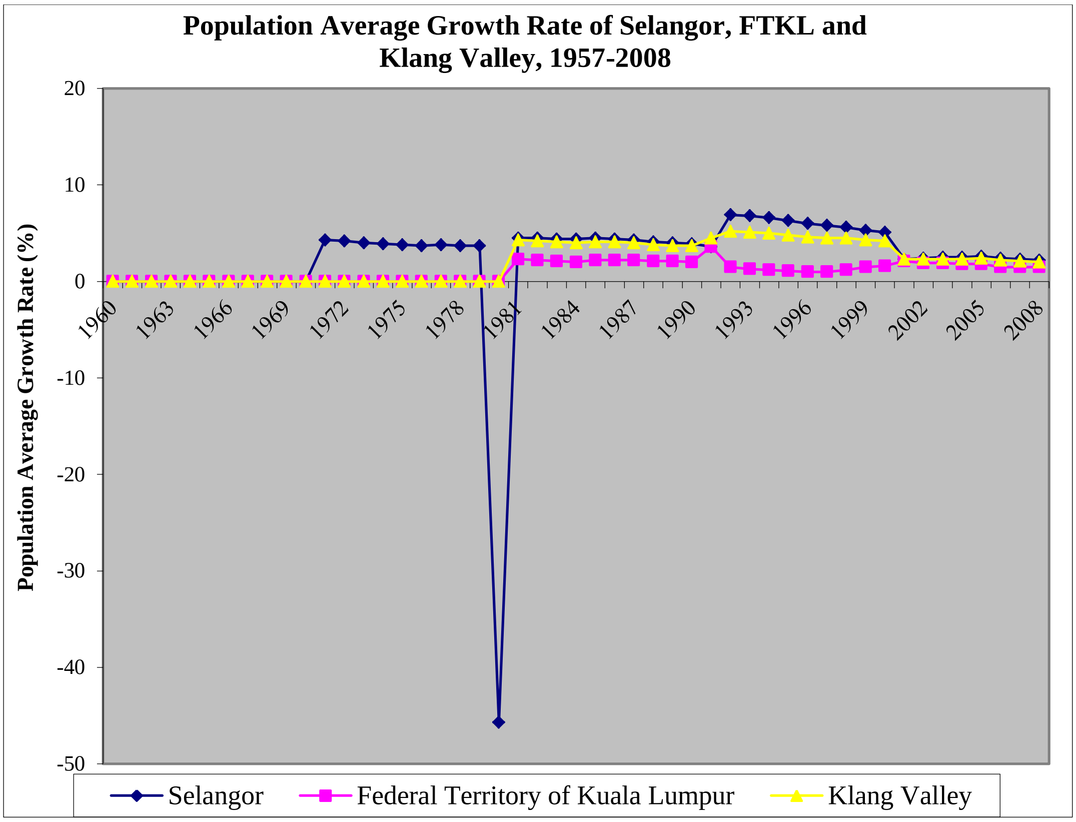

Figure 4.6 Population Growth Rate in the FTKL, Selangor and Klang Valley from 1957 to 2008

Sources: Department of Statistics Malaysia (2009) and the Ministry of Women Family and Community Development Malaysia (2009)

Note:

1970-1980 - Population based on estimated population census 1970-1980

1980-1991 - Population based on estimated population census 1980-1991

1991-2000 - Population based on estimated population census 1991-2000

2000-2008 - Projected population based on estimated population census 2000 - 2008

1970-1979 - Federal Territory of Kuala Lumpur under administration of Selangor

Klang Valley constitutes districts of Gombak, Klang, Petaling, Hulu Langat and Federal Territory of Kuala Lumpur

*Federal Territory of Kuala Lumpur includes KL Metropolitan and KLCC

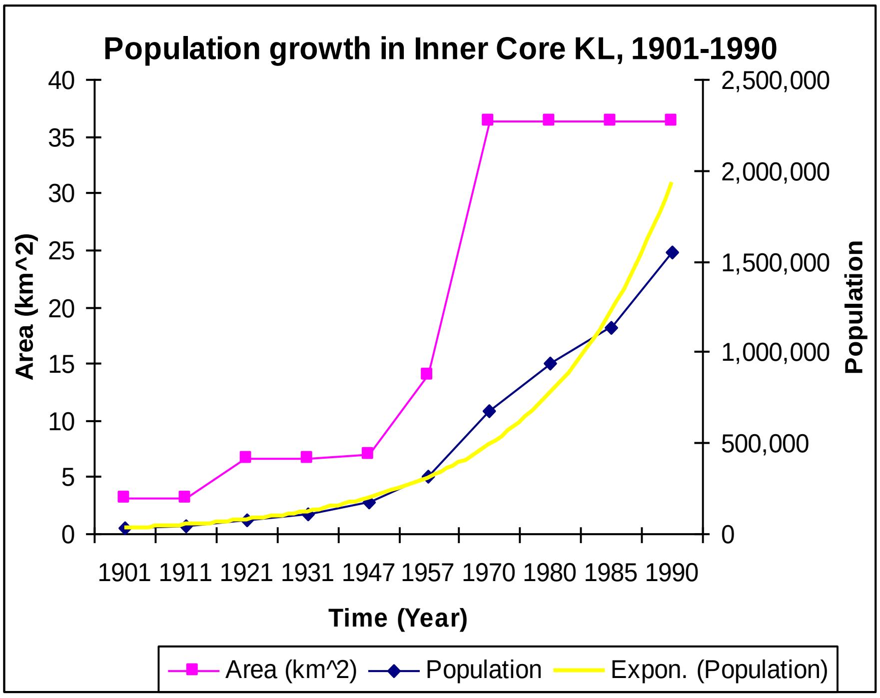

Figure 4.7 Population Growth in Inner Core KL

Source: Sen (1986) as cited by Lee (2009)

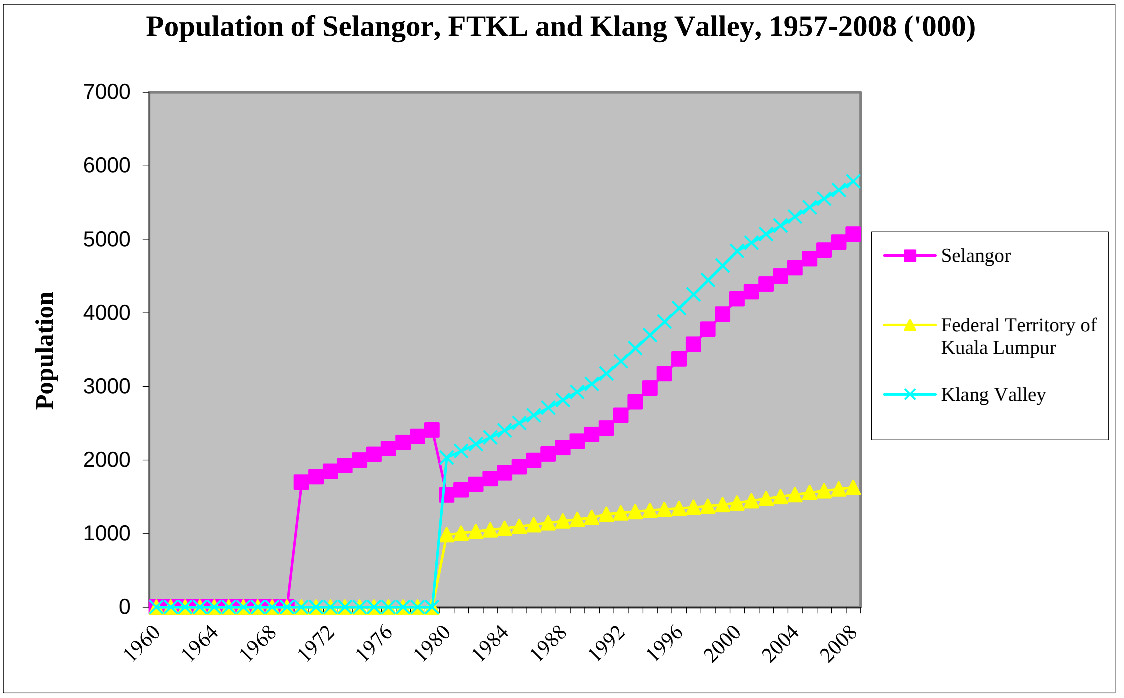

Figure 4.8 Population of Selangor, FTKL and Klang Valley from 1957 to 2008

Sources: Department of Statistics, Malaysia (2009) and the Ministry of Women Family and Community Development (2009)

Note:

1970-1980 - Population based on estimated population census 1970-1980

1980-1991 - Population based on estimated population census 1980-1991

1991-2000 - Population based on estimated population census 1991-2000

2000-2008 - Projected population based on estimated population census 2000

1970-1979 - Federal Territory of Kuala Lumpur under administration of Selangor

Klang Valley constitutes districts of Gombak, Klang, Petaling, Hulu Langat and Federal Territory of Kuala Lumpur

*Federal Territory of Kuala Lumpur includes KL Metropolitan and KLCC

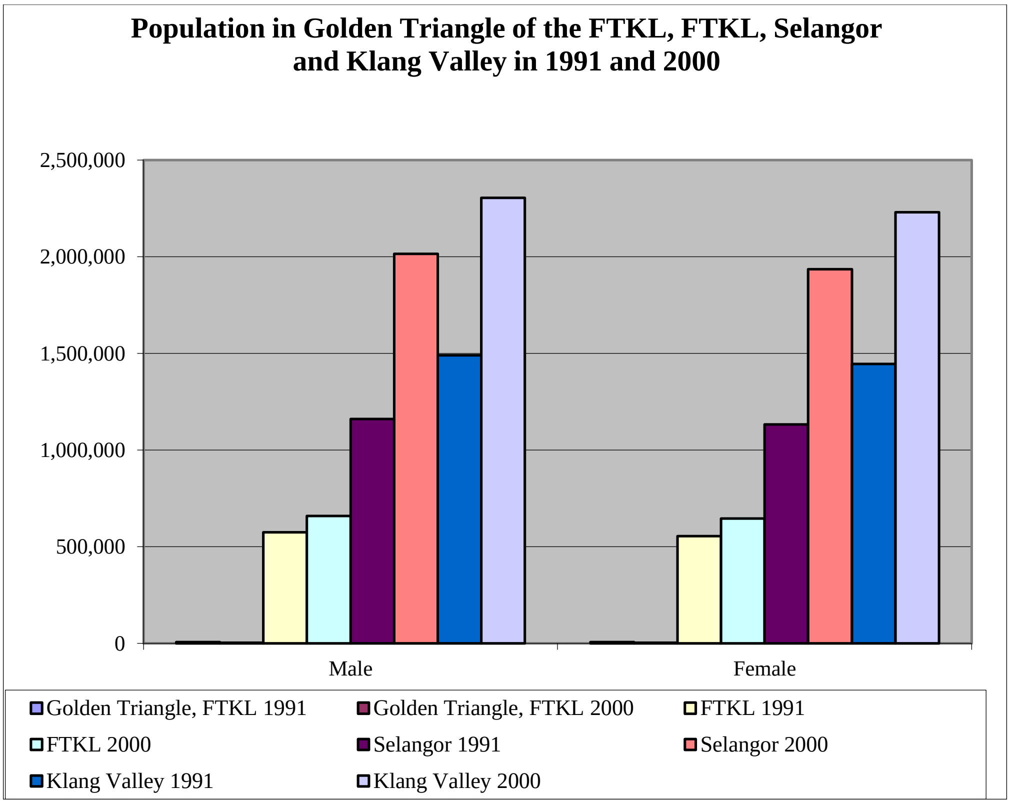

Figure 4.9 Population in the Golden Triangle of FTKL, FTKL, Selangor and Klang Valley in 1991 and 2000

<u>Source: Department of Statistics, Malaysia (2009)</u>

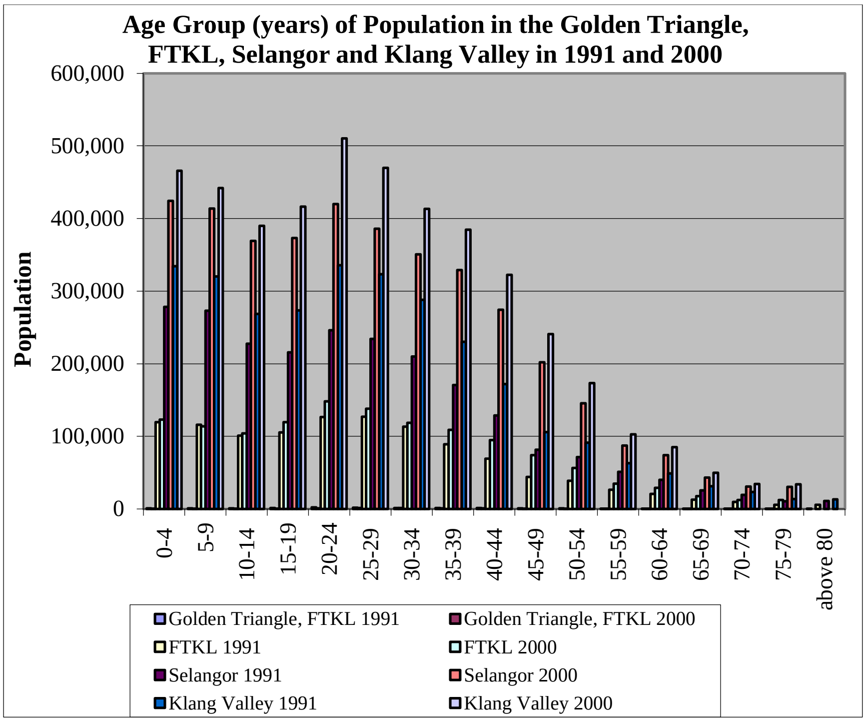

Figure 4.10 Age Group of the Population in the Golden Triangle, FTKL, Selangor and Klang Valley in 1991 and 2000

Source: Department of Statistics, Malaysia (2009)

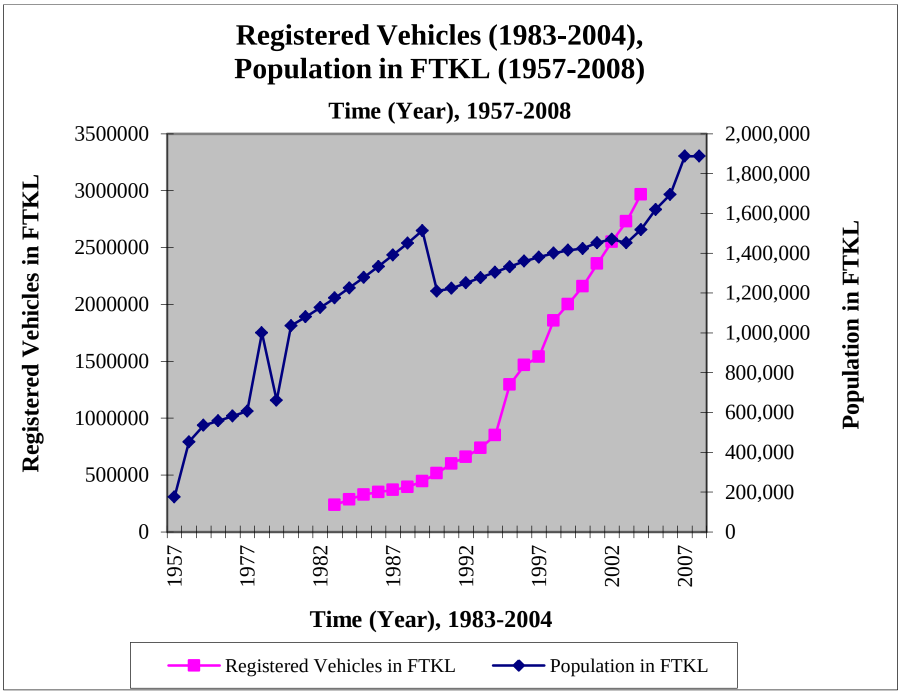

Figure 4.11 Total Registered Vehicles, Population Growth in Federal Territory of Kuala Lumpur, (1983 – 2008)

Sources: Jamilah and Amin (2007), Jamilah (1992), Chua (1983), Yap (2004), Silcock (1981b), mtransgroup, Rafia et al. (2003)

4.4 ECONOMIC DEVELOPMENT AND INDUSTRIALIZATION

The global economy swiftly transformed KL into a metropolitan setting with the mushrooming of landmark buildings, world-city skylines and world-class landscape. Such example is the Golden Triangle of Kuala Lumpur (Figure 4.12). KL's Golden Triangle is a core area that encompasses commercial, shopping and entertainment hubs. Popular places include the Bukit Bintang shopping complexes, the Bukit Bintang walk, the Petronas Twin Towers, Suria KLCC Mall, five-star hotels, prime office blocks, and the Asian Heritage Row (where converted colonial buildings are specially maintained). It is located to the northeast of the centre of the capital city. The borders of this triangle are defined by major roads, namely, Jalan Imbi, Jalan Sultan Ismail, Jalan P.Ramlee and Jalan Raja Chulan. It is clear that from its humble beginnings as a tin-mining town, KL has developed rapidly into a financial and business sub-sectors of the Malaysian economy. The percentage of jobs available in the central business district (CBD) and inner areas are relatively high, at 24% and 53%, respectively.

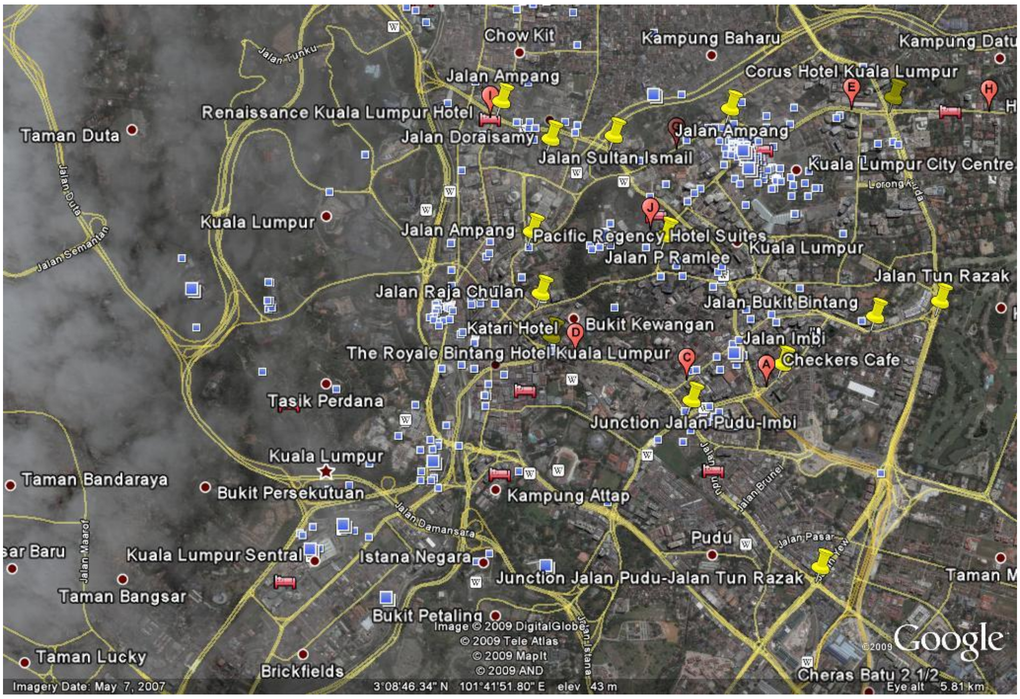

Figure 4.12 Placemark (Yellow) shows the Golden Triangle of Kuala Lumpur Metropolitan, Malaysia.

The primary diffusion corridor is a densely high concentration of industrial zones in Selangor and the KLCUR. Data-sets on working urban population in Malaya (perhaps Kuala Lumpur), 1947-1957 estimated that employment in manufacturing industries increased 7.5% while the mining and quarrying industries increased 22.6% and transport and communication, 11.4% (Hamzah, 1966). Between 1970 and 2000, a three-decade average growth rate per annum for the manufacturing industry was the highest, ranging from 11.6%, 13.5%, 5.2%, 13.7%, 13.3% and 9.9%. This was followed by the government services which comparatively recorded a 10.1%, 9.0%, 8.8%, 4.0%, 6.7% and 4.1% per annum growth rate. The gross domestic product (GDP) share of the services and manufacturing industries were 53.4% and 33.4% in 2000 (in 1987 prices), respectively (Ragayah, 2003, Zulina, 2003). These industries had an employment share of 38.1% and 10.6%, and 27.6% for non-government and government services, and manufacturing industries, respectively. During the first two decades, the Malaysian government managed to ensure the percentage of unemployment rate less than 7.5. Even though the financial crisis in 1998 had adversely affected the local economy on the whole, the average rate of unemployment was successfully minimized to less than 3.0%. Overall, the last decade recorded a percentage of unemployment rate of less than 5.1%.

Over the past two decades, and more specifically, since 1987 (Morikawa et al., 2001) KL had undergone a period of unprecedented economic growth (Alden and Awang, 1985) resulting in numerous mega projects. The rate of growth was 18.9% in 1985 and 1987 while Selangor's was 12.6%. In 2000, FTKL and Selangor contributed GDPs of RM25, 968 million and RM44,078 million in the 1987 prices, respectively. Accordingly, the GDP per capita for FTKL was RM30,727 and this value was about 1.8 higher than that of Selangor. KL and Selangor also displayed a high mean monthly gross household income for nearly three decades as can be seen in Figure 4.13. However, KL and Selangor faced negative rates of growth in 1997/99 due to the financial economic downturn with -7.2% and -3.9%, respectively (Ragayah, 2003).

With the increase in the KL's and Selangor's average income level, there existed an increase in the demand for private vehicle ownership. Such was the case of the residents of the city of KL in 1999 where 23.5% of KL households earned more than RM 5000 per month compared to 9.8% for Malaysia as a whole. Also in 1999, KL's average household income, as compared to the national average of RM 2472, was higher by 66.0% (Kuala Lumpur City Hall, 2005a).

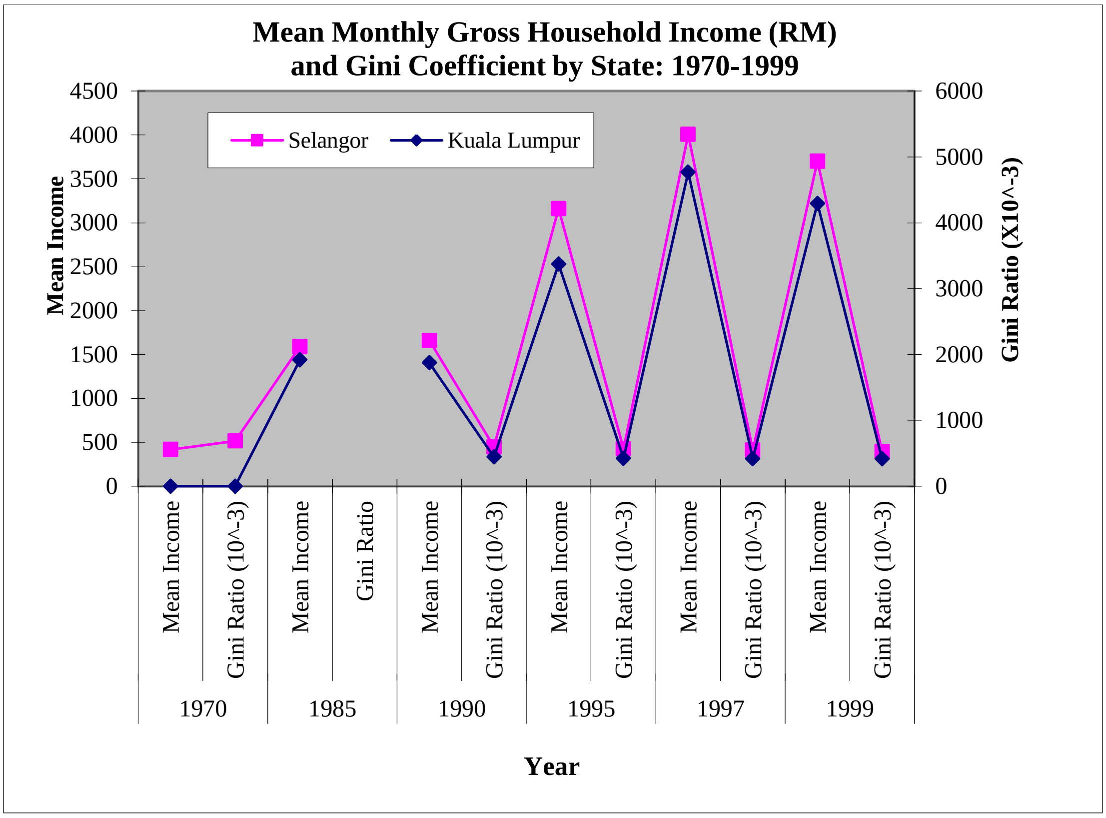

Figure 4.13 Mean Household Income (RM) and Gini Coefficient by State for 1970-1999

<u>Source: Ragayah (2003)</u>

Note: There was no recorded data on Gini Coefficient in 1985; Gini Coefficient is a measure of statistical dispersion, commonly used as a measure of inequality of income distribution or inequality of wealth distribution (Wikipedia, 2009).

Figure 4.14 presents the economic background of the population in Malaysia from 1970 to 2009. The 2007 mean monthly gross household income per Malaysian household was RM3686 (£759.35) while KL's mean monthly gross household income was RM5322 (£1096.38) (Figure 4.15), which was higher by 44.4%. KL's mean monthly gross household income i.e. RM5488 (£1130.58) was still found to be increasing in 2009 as shown in Figure 4.15 by 36.3% than the national mean of RM4025 (£829.19). The mean annual growth rate of household income for

Malaysia was 5.2% from 1995 to 1999 (Kuala Lumpur City Hall, 2005c) and it decreased to 4.4% from 2004 to 2009 (The Economic Planning Unit, 2010). Similarly for KL, it decreased more than 2.5 times from 5.0% to 1.8% for the period of 1995 to 1999 to 2004 to 2009. The mean annual growth rate of household income for Selangor was 2.9% between 2004 and 2009. The 2009 mean monthly gross household income per Selangor household was RM5962 (£1228.22). Recent estimated net food budget in Malaysian city was between RM775 (£159.66) and RM800 (£164.81) for a family of four members according to Noormahayu et al. (2009).

In 2007, 20.8% of Malaysian households earned more than RM5000 (£1030.04) per month. The second largest Malaysian household members were 15.8% who were paid between RM1000 (£206.01) and RM1499 (£308.81) per month. This percentage decreased slightly from 18.8% in 1999 for the same income class. However, there was a significant reduction for the income class of less than RM1000 (£206.01) where it was 8.5% in relative to 25.0% in 1999. While the percentages of household income distribution were quite consistent for the income classes of RM1500 – RM1999 (£309.01 - £411.81), RM2000 – RM2499 (£412.02 - £514.82), RM2500 – RM2999 (£515.02 - £617.82), RM3000 – RM3499 (£618.02 - £720.83), RM3500 – RM3999 (£721.03 - £823.83), RM4000 – RM4999 (£824.04 – £1029.84) from 1999, 2002, 2004 to 2007. From Figure 4.16, the national mean monthly gross household income in 2009 for both urban and rural was estimated at RM4705 (£969.27) and RM2545 (£524.29), respectively. In 2009, 90.6% of approximately 2.4 million Malaysians under the category of bottom 40% were the low income earners and the mean monthly gross household income for this category stood at RM1440 (£296.65). The top 20% earned an average of RM5600 (£1153.65) and above whereas the middle, 40% earned between RM2300 (£473.82) and RM5599 (£1153.44) (The Economic Planning Unit, 2010).

High income growth stimulated rapid motorization, which further encouraged KL residents to increase use of private vehicle and driving license ownerships in 2000. Also, there was a high tendency of car availability within the city households that had led to additional journey purposes and their length in view of income impact (Mackett et al., 2006). Data 2008 reported that private vehicles ownership rate was 1.89 cars per person (Leong, 2010). Approximately 986 cars and motorcycles per 1,000 population was registered in KL in 2000. This was 2.3 times higher than the national data (Kuala Lumpur City Hall, 2005c). Vehicle population was about 3.0 million within KL and its conurbations in 2008 (Leong, 2010).

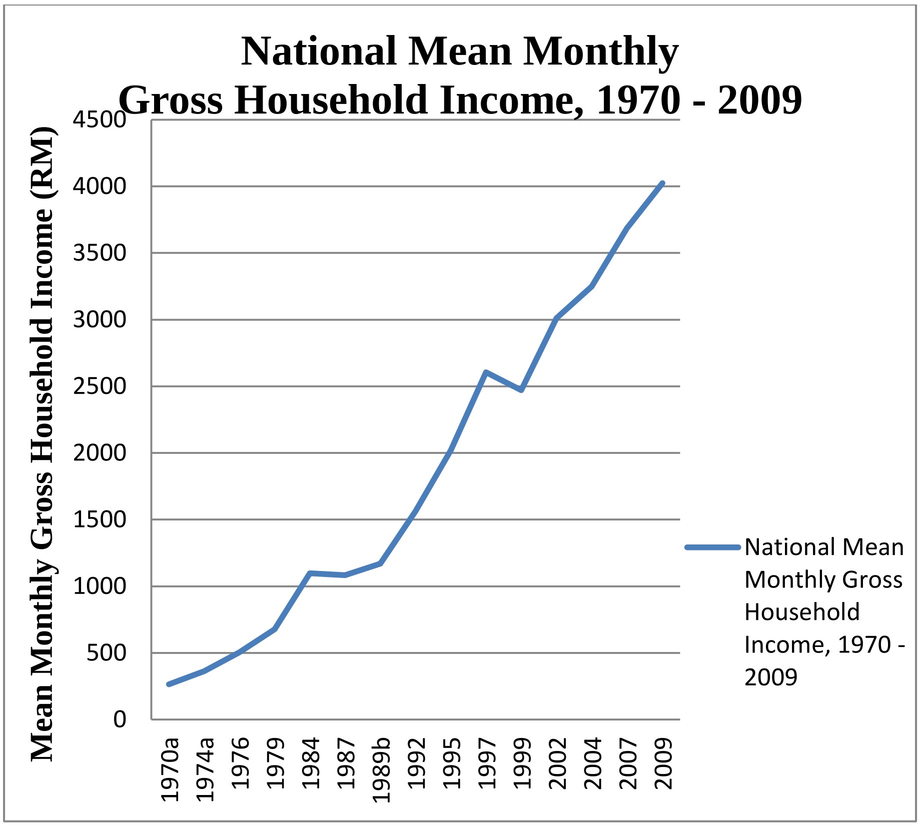

Figure 4.14 Mean Monthly Gross Household Income in Malaysia from 1970 to 2009

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Sources: Economic Planning Unit,
Prime Minister's Department (2010),
Department of Statistics, Malaysia (2010), and MalaysiaEconomy (2010)

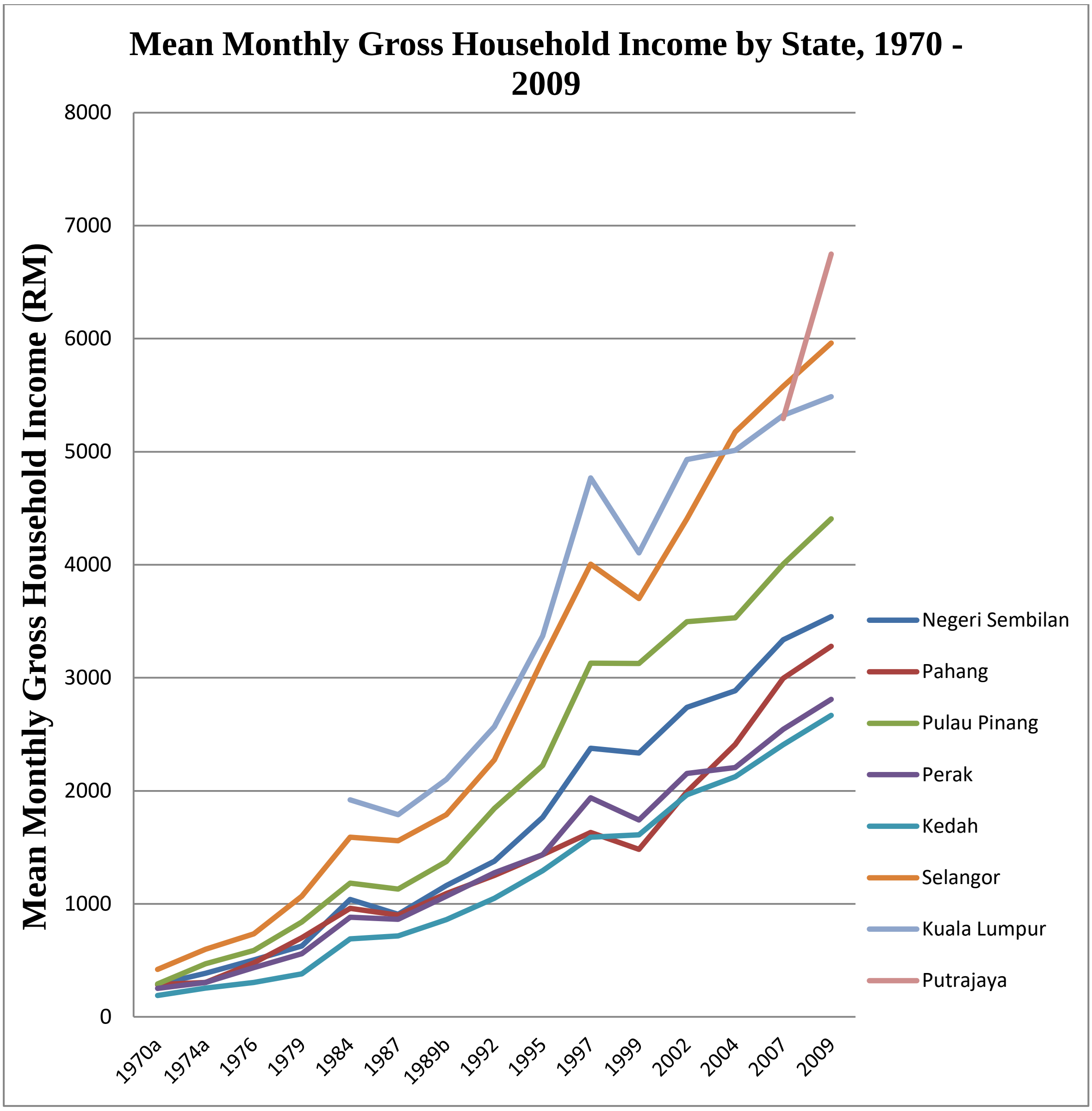


Figure 4.15 Mean Monthly Gross Household Income by State from 1970 to 2009

Sources: Economic Planning Unit, Prime Minister's Department and Department of Statistics, Malaysia (2010) and MalaysiaEconomy (2010)

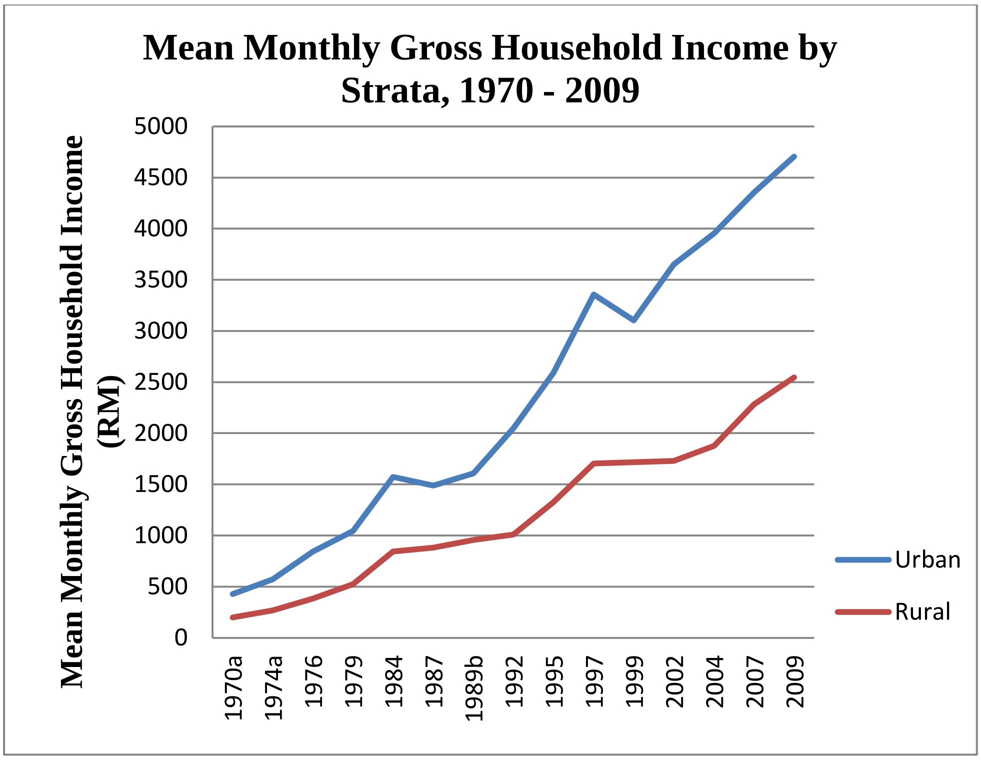


Figure 4.16 Mean Monthly Gross Household Income by Strata from 1970 to 2009

Sources: Economic Planning Unit, Prime Minister's Department and Department of Statistics, Malaysia (2010) and MalaysiaEconomy (2010)

4.5 MOTORIZATION

From the mid 1980s, the economic, population and urban growth in total contributed to a sizeable progress in the manufacturing industries and sales of national cars and motorcycles, namely, Proton, Perodua, and Jaguh and Kriss. They also speedily expanded the rate of mobilization (Chuen et al., 2014). KL city alone had 985.7 cars and motorcycles per 1000 population in 2000 compared to 421.9 per 1000 population for Malaysia as a whole, thus, indicating a rate twice that of the national average (Kuala Lumpur City Hall, 2005). It did not come a shock that KL was one of the most car-dependent cities in the world.

Motorization had direct bearing on the transportation sector in Malaysia. It accounted for 40% of Malaysia's total energy consumption (Khoo and Ong, 2015). The national car industry depended largely on domestic sales (Azman, 2006) because of its lower price resulting from the effort undertaken by the National Automotive Policy of which was to protect Malaysia-manufactured cars by imposing high taxes on imported vehicles (Khoo and Ong, 2015). From mid 2005, the hike of fuel price had driven the government to impose a fuel subsidy for the benefit of the nation. Fuel prices were strictly governed and were among the lowest in the ASEAN region at RM$1.92 (USD$0.58) per litre for petrol and RM$1.58 (USD$0.48) per litre for diesel. Road users were fortunate that they were not subjected to total travel cost (Kasipillai and Chan, 2008b).

Changes in income levels influenced the processes in motorization as graphically presented in Figure 4.17 (Barter, 2004). Malaysia's recent rapid growth in car ownership particularly in KL and Selangor offer evidence that rising incomes were the major driving force for car ownership (Jamilah, 2003, Barter, 2004, Mustafa, 2005). The immediate impact was that society could afford to own personal vehicles and the market prices of the national motor vehicles and incentives provided by the government spurred the growth of vehicle ownership. Such incentives included car loans and staggered payments for government staff. Figure 4.20 exemplifies the estimated relationship between vehicle ownership and per-capita GDP.

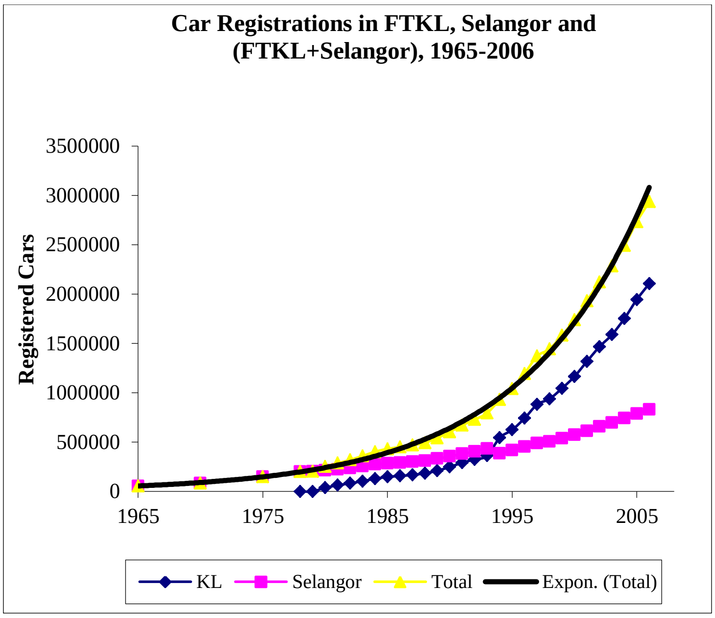


Figure 4.17 Car Registrations in FTKL, Selangor and (FTKL+Selangor), 1965-2006

Sources: Data-sets from Ministry of Transport Yearbooks and MOT 1975-86 as cited by Jamilah (1992, 1994), Rafia et al. (2003); Department of Statistics Malaysia (2000-2006)

Note: There was no recorded data in 2002 because no traffic census was carried out.

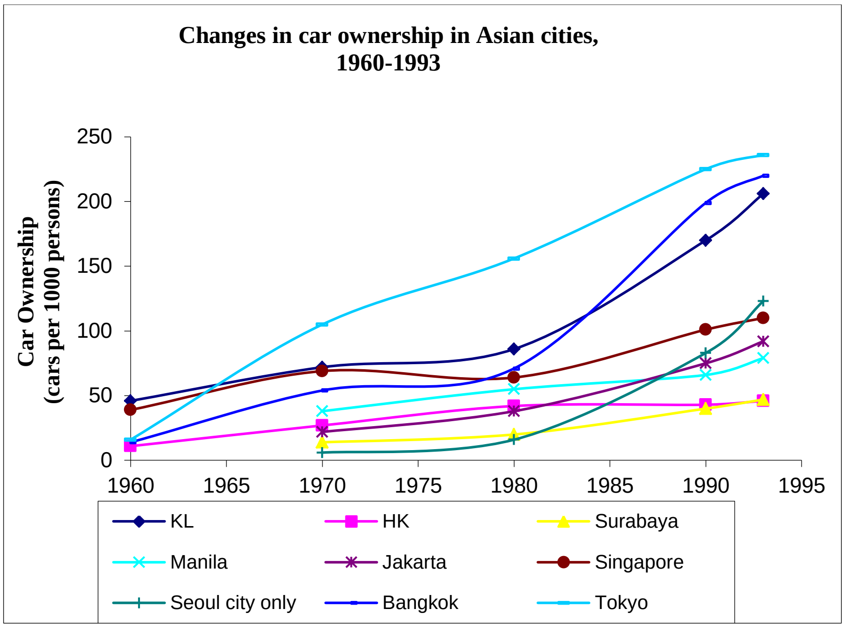


Figure 4.18 Car Ownership in KL and other Asian cities, 1960-1993

Sources: Marcotullio and Lee (2003) and Rafia et al. (2003)

Note: KL's 1960 car ownership data is for 1963. Tokyo's figures are for Tokyo only.

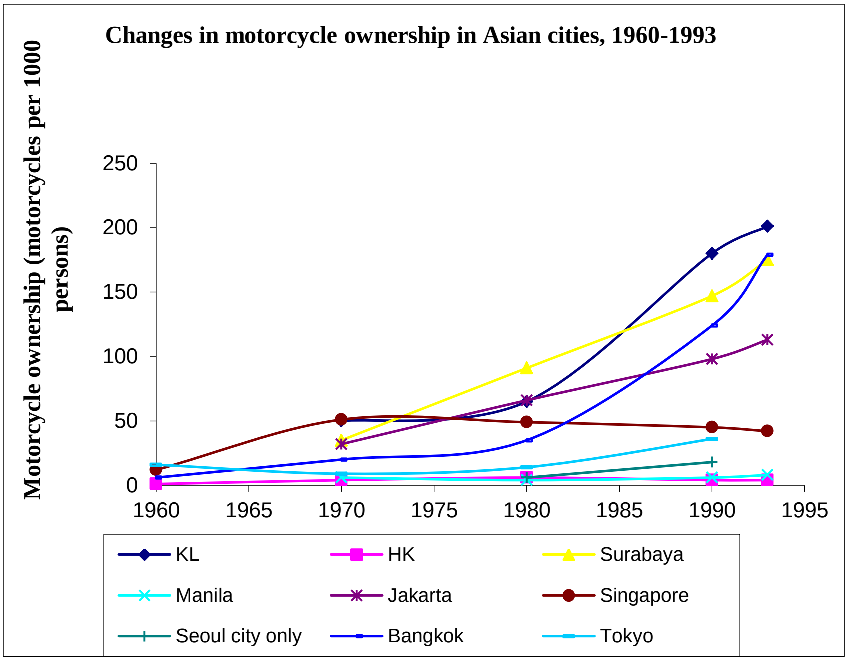


Figure 4.19 Motorcycle Ownership in KL and other Asian cities, 1960-1993

Sources: Marcotullio and Lee (2003) and Rafia et al. (2003)

Note: KL's 1970 figures are for 1972, Surabaya's 1970 figures are for 1971, and Jakarta's 1970 figures are for 1972. Tokyo's figures are for Tokyo only.

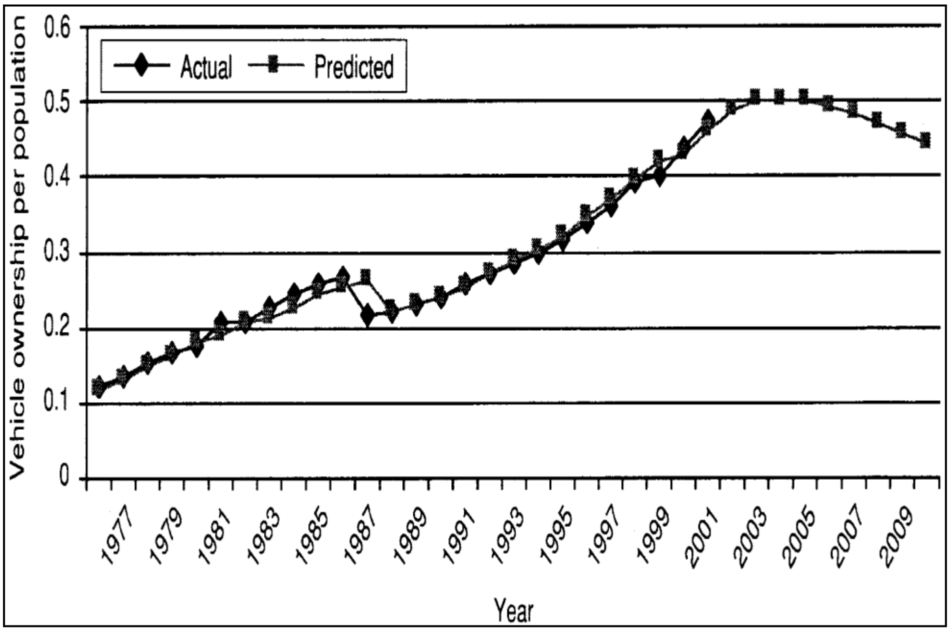


Figure 4.20 Vehicle Ownership Estimation and Projection, (1976 – 2010)

Source: Law et al. (2005)

4.6 DECLINE IN PUBLIC TRANSPORT

After the economic recession of 1986-1988, the number of registered vehicles (i.e. cars and motorcycles) increased at a faster rate, from 3.3% in 1987 to 9.5% in 1990 (Rafia et al., 2003), +13.3% from 1985 to 1997 (Table 4.2) based on the Klang Valley Transportation Studies conducted by the Japan International Cooperation Agency,JICA in 1984-1987 and the Study on Integrated Transport Information System (ITIS) in Klang Valley and the MSC in Malaysia for the Malaysian Highway Authority, respectively (Japan International Cooperation Agency, 2005, Jamilah et al., 2001). Townsend (2003) confirmed that motorised private modes formed 69% of the mode split of all trips in KL in 1995. Results of the worktrip travel survey 1993 as reported by Jamilah (1994) also presented that car availability at the individual level was the major determinant of car trips to work. This study managed to empirically prove that a dire need for a car may also reflect the lack of suitable alternative public transport. The study revealed that a majority of the respondents considered bus transport as undesirable due to overcrowding, discomfort and long journey times. From the mid 1990s, the investment in road construction was estimated to be 1.9% of the KLMA Gross Regional Product or more than US$200 per person per year, which was considered quite high for a middle-income city (Barter, 2002, Barter, 2004, Bunnell et al., 2002). Another issue was that transportation infrastructure was one of the major sectors that was subjected to privatisation in Malaysia (Abdul-Rashid, 2006), thereby speeding up road development in all of KL suburbs. Despite continued mega road infrastructure projects made towards improving the KLMA, the use of city bus services declined abruptly in the mid-to-late 1990s (Jamilah, 1995, 1997; Bunnell et al., 2002; Hilmi; Takatsu, 2003; Jamilah and Amin, 2007; Kasipillai and Chan, 2008). Interesting data were highlighted by Barter (2004) that the percentage of trips by public transport modes in the Klang Valley dropped from 37.0% in around 1970 to 33.0% in 1980, and 32.0% in 1990. Tables 4.1 and 4.2 illustrate the above findings.

In the mid-1980s recession, JICA through a 1981-Davao Urban Transport cum land use study actually correctly recommended the application of urban public transport and its modernisation based on city size (Zulina, 2003), but it could be implemented with the existence of under-designed quantity and quality of city bus services as justified by Walters (1979); Rimmer (1986); Jamilah (1995, 1997); Barter (2004).

Between 1985 and 1997, KL saw a very rapid decline in the modal share of its public transport system from 34.3 to 19.7% (Table 4.2 and Figure 4.21) (Jamilah et al., 2001; Morikawa et al., 2001, 2003; Barter, 2004; Norlida et al., 2006; Hossain and Mak, 2007). The corresponding buses'share was 34.3% in 1985. The share of stage bus/minibus dwindled alarmingly from 17.7% in 1985 to 7.9% (but 6.0% according to Table 4.2) in 1997 as further specified by Jamilah et al. (2001) and Morikawa et al. (2001, 2003). The KL roads were radial and were dominant in the city centre. A majority of roads around the central part were arterials. The bus routes covered 67.0% of the population. Although these routes were narrow, they provided reliable network coverage (i.e., a 350-m radius from the stops) since 1997 (Jamilah et al., 2001; Jamilah, 2003). Jamilah (1995) reported that stage buses accounted only for 40-45% of the total KL conurbation based on the KL Master Plan Transportation study done by Wilbur Smith and Associates in 1981. The services of minibuses in 1995-1996 were stopped due to the ignorance of the bus drivers towards traffic regulations. Bus drivers haphazardly took their own routes. These led to mixed (chaotic) traffic during peak hours causing sudden irregularities (Wan Shazilina, 2003; Barter, 2004) or low frequency of city bus services. So, bus users suffered due to longer waiting time (Zulina, 2003) and overcrowding at the stations/stops. The transport authorities in FTKL also faced the problem of inadequacy in the level of services provided by the bus operators in terms of overlapping bus networks and poor bus conditions (mtransgroup, 2003). Rise in operation costs together with the lack of resources were also causal factors. Several measures to increase use of bus had not been seriously enforced (Jamilah, 1992; Barter, 2004). The results of the SMURT-KL study by JICA in 1997-98 forced the Kuala Lumpur City Hall (2007) to consider area licensing or pricing systems in the central district to reduce congestion (Sugawara, 1995; Jamilah and Amin, 2007; Abdul-Rashid, 2006; Kasipillai and Chan, 2008). This attempt was, however, abruptly suspended due to inadequacy of public transport (Jamilah, 1995, 1997; Kasipillai and Chan, 2008), i.e., stage/minibuses (-11.6%), rail-based transportation (+1.2%) and feeder bus (+0.3-0.4%) in 1997. Bus lanes on KL major roads were given minimal benefits due to lack of enforcement since 1997 (Siti Nurbaya, 2003, Wan Shazilina, 2003).

Table 4.1 Physical investments and percentage of public transport services utilization for KLMA

Year	Physical Investments	Percentage of Public Transport Use
1995	Suburb rail commuter system: KTM Rawang-Seremban line KTM Port Klang-Sentul line	-
1996	LRT system: Ampang/Sri Petaling line	-
1998	LRT system: Kelana Jaya line	19.7
2001	Multimodal transportation hub: Opening of nation's biggest urban multimodal transportation hub, the KL Sentral Station	-
2003	Monorail system: Opening of the innercity KL Monorail system	16.0

Source: Norlida et al. (2006)

Table 4.2 Percentage of Share of Modes of Transportation in the KLMA

Modes of Transportation	Percentage of Share (%)		
	1985	1997	Difference
Car	33.8	42.9	+9.1
Motorcycle	13.8	18.0	+4.2
Stage Bus/Mini Bus	17.7	6.0	-11.6
Factory Bus /School Bus	7.2	7.7	+0.5
Rail-based transport	-	1.2	+1.2
Non-motorized transport (walk and bicycle)	27.6	23.9	-3.7
Other modes	-	0.3	+0.3

Source: the Malaysian Highway Authority (1999) as cited by Zulina (2003)

80% of the Klang Valley Public Transport (KVPT) corridors were outside reliable rail transit (Barter, 2002; Hossain, 2007; Jamilah and Amin, 2007). The two- and three-kilometre radius network coverage of feeder buses from stations was no longer wide enough and unreliable. Rail services were distinctly far less accessible than bus services due to shortage of transfers with at least two rail-feeder bus systems for urban public transport trips. Their ability to service patrons on a single one-way trip was also very limited.

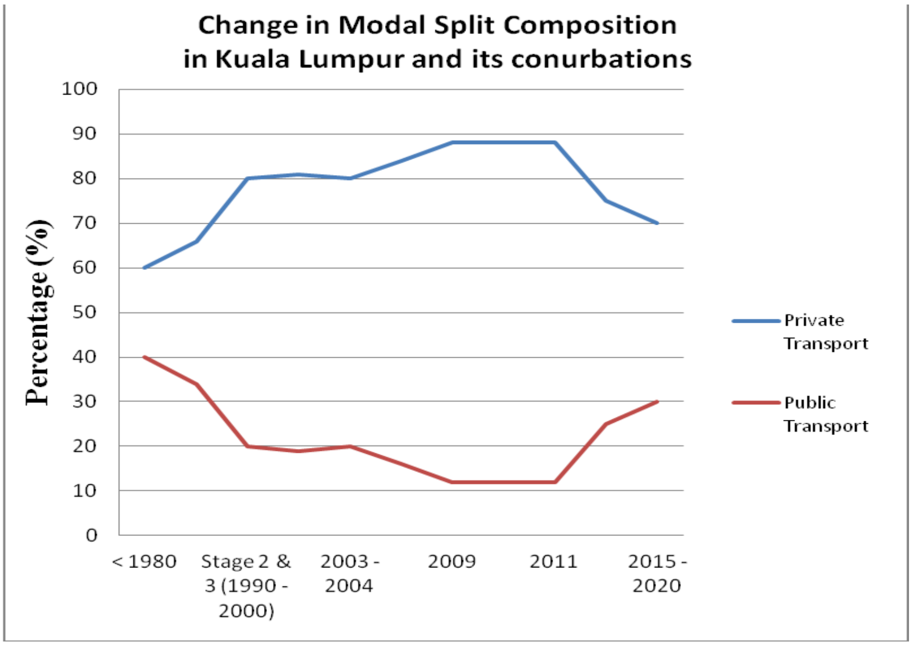


Figure 4.21 The Modal Split Composition in KLC from before 1980 to 2020

Sources: Economic Planning Unit, Prime Minister's Department and Department of Statistics, Malaysia (2010), Leong (2010), The Economic Planning Unit (2010) and Adibah (2007)

A small-scale survey of Klang Valley Public Transport (KVPT) was carried out by mtrans in Malaysia University of Science and Technology (MUST) (2003) based on passenger rating of the service characteristics of KVPT. The findings summarized that a major source of customer dissatisfaction towards service characteristics of KVPT ranged from uncertainty (65%), low quality of service (longer waiting time, discomfort) (51%), to difficulty of access (high cost) (41%). By contrast, results of *KTMB* Customer Satisfaction Survey 2004 confirmed *KTM Komuter* services meeting the travelling needs of almost 100% respondents, ranging from below RM1000 to above RM3000 of monthly income groups. Interestingly, 40% of the *KTM Komuter* users were those from the higher income group (earning above RM3000). Causal factors for travelling by *KTM Komuter* estimated that 29.0% of the users were actually avoiding traffic jams, 23.0% found it convenient, 17.0% lived near stations, 16.0% found the services fast, and 12.0% opined *KTM Komuter* to be comfortable. Ongoing improvements to the overall Klang Valley bus network were being facilitated by the Urban Transport Department-the Integrated Transport Information System (ITIS) of the Kuala Lumpur City Hall and the Highway Planning Unit of the Ministry of Works with respect to providing frequent services, comfortable and convenient rides or trips.

Figure 4.32 indicates that stage bus accidents were higher than accidents involving taxis from 1997 to 1999 in KL and Selangor. This scenario also reflected a major shift from utilising public transport mainly that of buses.

LRT passengers, on the other hand, largely depended on government policies to spur a modal shift from private to public transport use (Hine and Grieco, 2003; Tan, 2008). Both STAR and PUTRA increased ridership very slowly in the early operations. This was supported by Abdul-Rashid (2006), Sock (2006) and Sock (2007) who documented that LRT suffered low ridership that was no more than one third of the projected daily ridership for 2000, 2005 and 2010 (Figures 1.6 and 4.16). STAR re-used the old tracks and was plying already low populated areas, resulting in lower passengers compared to PUTRA. PUTRA faced land acquisition problems due to developers not co-operating with regard to their land (Tan, 2008). KL Monorail encountered the same problem as PUTRA. Its final station had to be offset 150 metres from KL Sentral. May et al. (2006), Grotenhuis et al. (2007) and Syahriah et al. (2008) explained the meaning of integration at the operational level as integration of fares, services (i.e. routes and vehicles) and information provision within public transport. The LRT also faced lack of operational integration at the multimodal level and within each system, including providing reliable facilities (Jamilah, Sugawara, 1995; Jamilah, 1997; Bunnell et al., 2002; mtransgroup; Zulina, 2003; Malaysian Strategic Research Centre, 2006), adequate network coverage (Hossain, 2007); and consistent price regulations (and subsidies), thus making fares unreasonable (Syahriah et al., 2008). Sugawara (1995) and Topp (1999) highlighted that the line density of railways was small, requiring the feeder buses to be integrated so that the railways could serve their roles more efficiently. The government provided ‘park-and-ride’ facilities only at certain LRT stations.

High capital investment was also needed to build as well as expand networks, not just to meet projected passenger growth, but to increase ridership through sufficient network coverage. This was why the private sector was unable or unwilling to wholly finance rail development before the 1997-98 Asian financial crises. Rail operators had to rely on substantial subsidies and grants to meet this cost of capital. This explained why many cities had to support the cost of infrastructure provision (Sugawara, 1995; Hilmi; Takatsu, 2003; Ahern and Anandarajah, 2008; Tan, 2008).

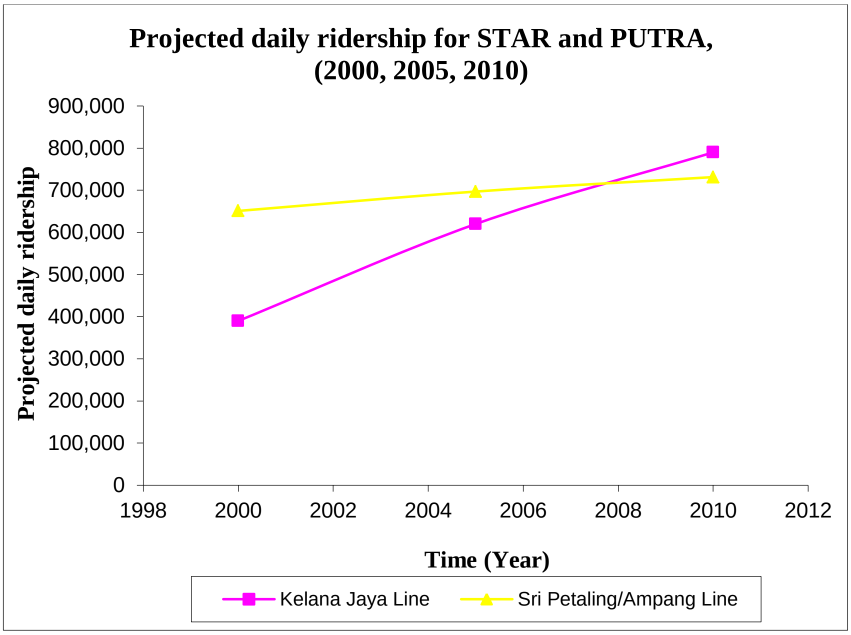


Figure 4.22 Earlier Projection on Daily Ridership for STAR and PUTRA, (2000, 2005, 2010)

Source: Haji Zakaria (2002) as cited by Abdul-Rashid (2006)

In 2002, both STAR and PUTRA did not have enough financial backing to settle their debts. The government via Syarikat Prasarana Negara Berhad (SPNB) paid the amount due. However, the actual average daily ridership gazetted by the Economic Planning Unit of the Prime Minister's Department (2001) for 1998-2008 was far much beyond than those projected earlier. Abdul-Rashid (2006) argued that ridership could be low because of potential competition and financial woes.

From 1998 to 2002, the shares of the KL public transport remained at 20% (Department of Statistics, Malaysia 2001 cited in mtransgroup, 2003) as can be seen in Figure 4.21. Rail services recorded 10% out of 16% of the KL public transport modal split 2003 as illustrated in Figure 1.7 (Norlida et al., 2006; Hossain, 2007). Stage buses/minibuses continued to decrease to 6.0% (Hossain, 2007).

From Figure 4.21, it can be noted that private cars dominated 78.2% of the modal share whereas public transport contributed to 21.8% (buses, 20.0%; rail travel, 1.7% and air travel, 0.1%) of the share of passenger transport modes in Klang Valley. This was registered by the Ministry of Works in 2005 (Malaysian Highway Authority, 2006). The restrain of private vehicle use was obviously unsuccessful as it contradicted the National Automobile Policy.

In mid 2005, rail transit system served to be a better alternative transport to KL city residents due to the strong effects of oil price hike and heavy traffic congestion (NurAkmal Goh et al., 2006). Fewer commuters (16%) used public transport in KL and Selangor in the end of October 2005 (Norlida et al., 2006). Between 2005 and 2007, the performance of RapidKL buses also declined due to unreliable services, insufficient capacity (i.e., load factor for RapidKL buses was 140%), and high accident rates of stage buses in KL and Selangor (Figures 4.31 and 4.32). These conditions might well explain the parallel increase in rail transport (Kelana Jaya line, Ampang/Sri Petaling line, KTM Komuter, and KL Monorail) in mid 2004 to 2008 (Figure 1.5).

The situation remained the same in 2006 and 2007 (Kasipillai and Chan, 2008a) as illustrated by Law et al. (2005) and the national rail services and ridership data (Chua, 1983, Keretapi Tanah Melayu Berhad, 2012, Ministry of Transport Malaysia, 2009b) and as displayed in Figures 4.15, 4.24 and 4.25. No legal action probably induced the growth of vehicles to 8% (Figure 4.23) (Kasipillai and Chan, 2008). Such figure was far much behind other major Asian cities like Seoul (60%), Singapore (56%), Manila (54%), Tokyo (49%), and Bangkok (30%).

Many agencies shared the responsibilities for governing KLMA public transport (Barter, 2004). There was poor coordination and integration in transport planning and management at a larger scale (Gwilliam, 1999; mtransgroup, 2003; Syahriah et al., 2008). Even the technical staff had no opportunities to get involved in the related issues at the state and local levels (mtransgroup, 2003). The Public Transport Local Authority was established in 2005. However, this committee was not committed to its scope of work. Absence of a regulatory mechanism (Gwilliam, 1999; Barter, 2004; Jamilah and Amin, 2007; Tan, 2008) and enforcement of public transport services (operational and the administrative management) prompted poor service in the public transport system. Railway operators operated on realistic fares on the bases of being business-oriented. Gwilliam (1999) further justified that people in several Asian countries were far more concerned about the availability and quality of public transport. They did not bother about the price of the service.

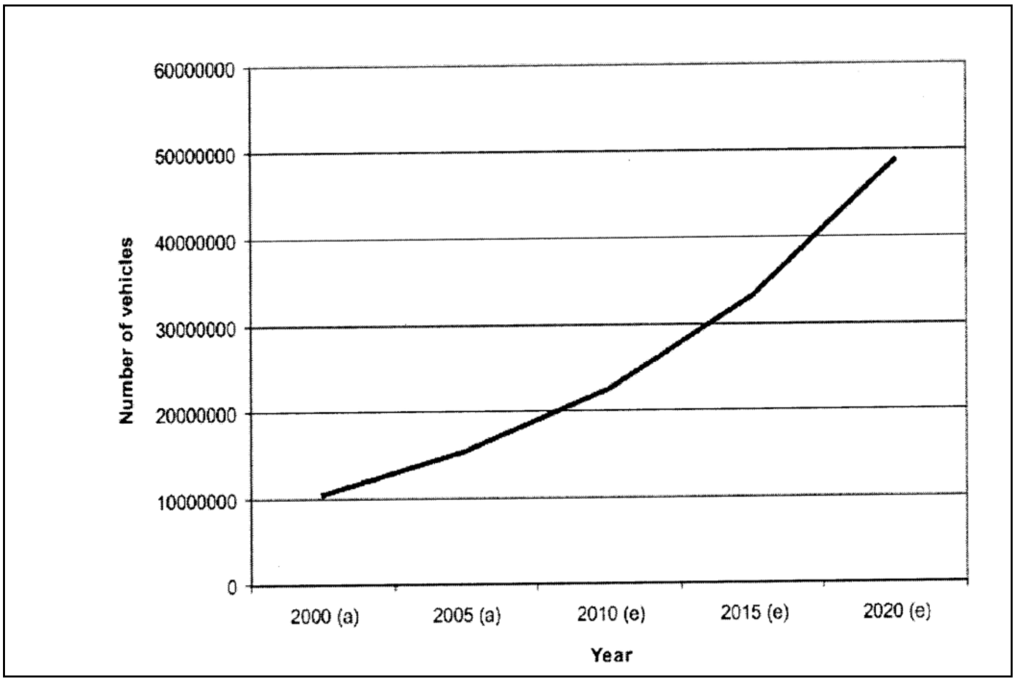


Figure 4.23 Number of Vehicle Estimation and Projection in Malaysia, (2000–2020)

Note: a = actual, e = estimated;

Sources: Abidin et al. (2004) as cited by Kasipillai and Chan (2008) and Department of Statistics, Malaysia (2006)

Figure 4.24 illustrates a loss of short trips as this train was the only national inter-city train concentrating more on the major cities and big towns at the rural-urban areas and borders. For short trips, users had many options such as using a car, motorcycle, or city bus like Rapid KL and Metro bus, and rail rapid transit system. Moreover, the low speed of the inter-city trains on the narrow gauge tracks made them uncompetitive with other modes of transportation. Figure 4.25 indicates an increase in the length of million passenger kilometres from 1992, yielding a longer mean passenger trip, i.e., 291 passengers per km. This showed that users had few choices of long distant-travelling out of the main cities to avoid the expected heavy traffic jams on the expressways and highways during the festive seasons and school and public holidays in addition to travelling in leisure, comfort and convenience. *KTM Komuter* promoted travel packages called *'Ronda-Ronda KTM Komuter'* such as a one day in KL trip (from RM22.00 per person), a one day in Seremban trip (from RM30.00 per person), a one day in Pulau Ketam trip (*'Crab Island'*) (from RM35.00 per person), and a two-day one night fishing trip in Pulau Ketam (from RM88.00 per person). It offered expensive fares, but the trips and fares were worthy.

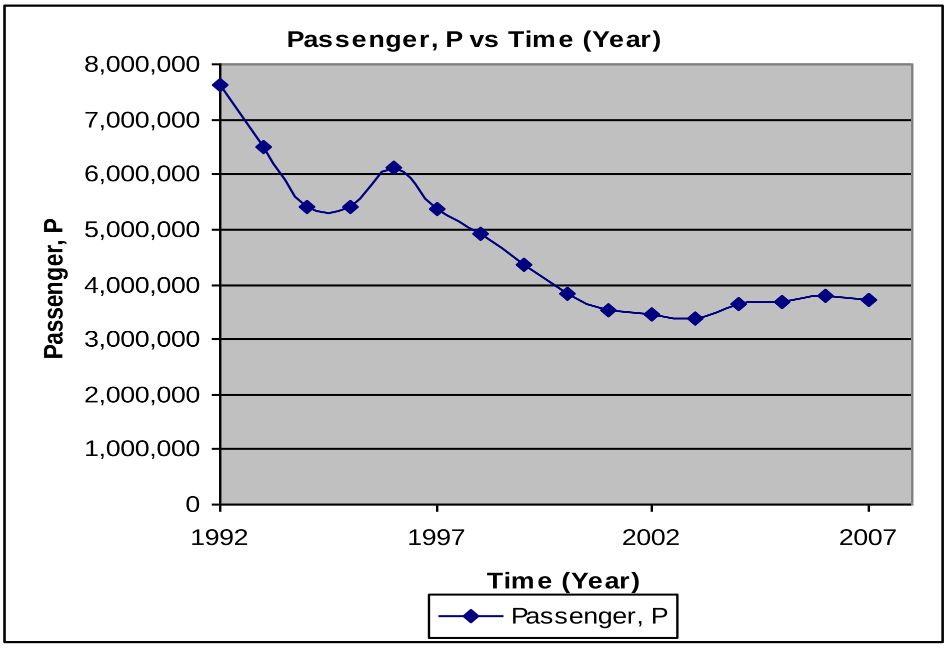


Figure 4.24 *KTMB*'s Rail Passenger Services and Ridership, (1992-2007)

<u>Sources: Chua (1983), KTMB, Ministry of Transport Malaysia (2009a)</u>

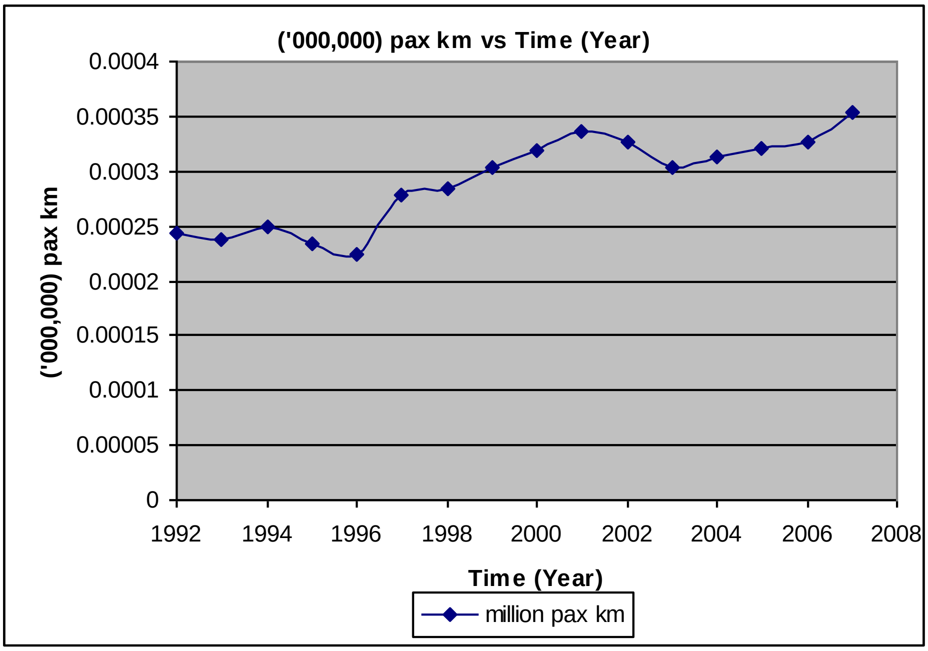


Figure 4.25 *KTMB*'s Million Pax Kilometre vs Time, (1992-2007)

Sources: Chua (1983), KTMB, Ministry of Transport (2009a)

With regards to population, Figure 1.5 illustrates that the number of rail passengers grew at a slower rate than that of the population of KL. From Figures 1.5 and 1.8, it can be seen that although an overall pattern of substantial growth is notable in three rail transport systems from 1995 to 2007, KL Monorail from 2003 to 2007, and the Express Rail Link (ERL) services from 2002 to 2007, the rate of growth at least lessened the overall decline in public transport usage. Two distinct factors caused the unfortunate early operations of the rail services since 1996. First was the minimum usage of the bus system (1995 onwards), particularly feeder bus services (Hilmi; Jamilah, 2003; Barter, 2004). Second was the Asian economic downturn (1996-1997) that brought about an abrupt reduction in ridership for the national rail services in the late 1996 as can be seen in Figures 4.24 and 4.25, while the former was confirmed by Hayashi et al. (2004) as illustrated in Figure 4.26. The

Asian financial crisis slowed down the demand for LRT. Abdul-Rashid (2006) stated that bus services managed to competitively sustain itself compared to the LRT (Figure 1.6). Figure 1.8 shows that between 2001 and 2005, there was a significant increase in the LRT ridership because of a few major changes in or expansion completions to its services. Such changes included some LRT routes being upgraded and widely operated (A'zizan, 2006). To upgrade the lines of the Kelana Jaya line, Syarikat Prasarana Negara Berhad (SPNB or Prasarana) purchased 88 new Advanced Rapid Transit (ART) Mark II in October 2006 (Glickenstein, 2007). Prasarana was also offered another 52 vehicles. This was to increase ridership to more than double on the line to about 370,000 passengers per day. Unfortunately, Kelana Jaya line's track extension proposed in August 2006 to Bandar Sunway, Subang Jaya and UEP Subang Jaya suburbs have not been constructed to date.

Figures 1.5 and 1.8 illustrate that KL Monorail's ridership was likely to grow as standards of service and accessibility were improved. KL Monorail was expected to gain profits by 2007 with a projected average annual net profit of RM82 million (RM561 million revenue) for 2007-10 and an exponential increase to RM1.66 billion (RM3.03 billion revenue) for 2011-20 (Tan, 2008). However, the auditors' in KL Infrastructure Group's financial statements for the year ended 30 April 2006 documented that KL Monorail was unable to reach targetted profits after 2007.

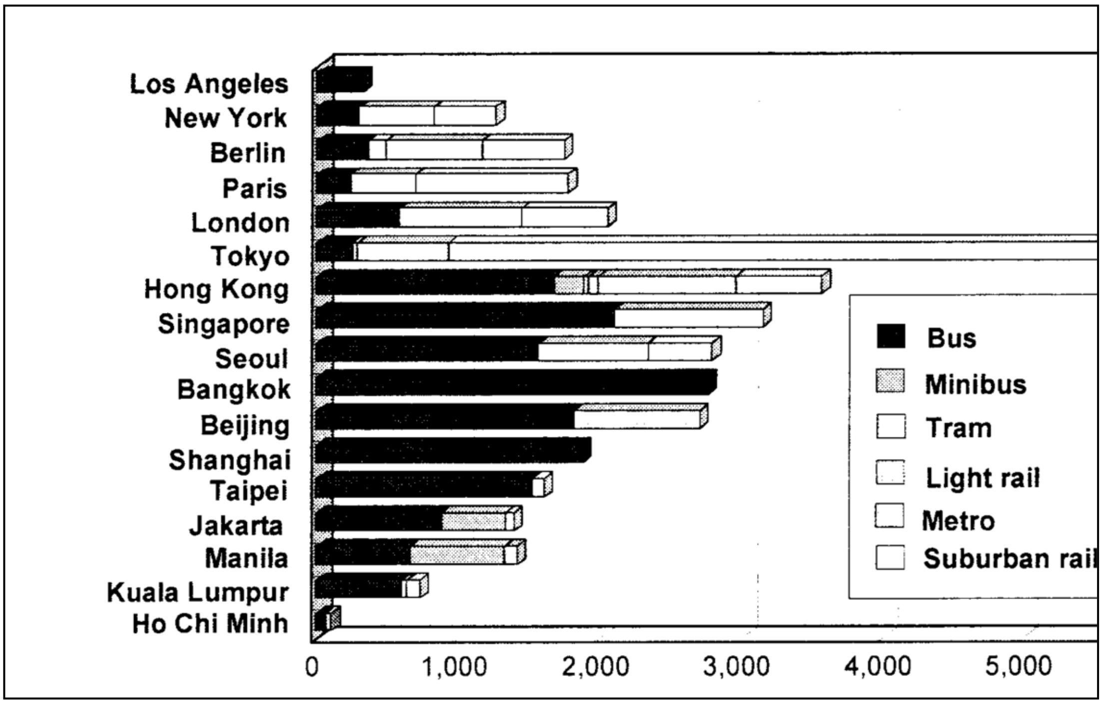


Figure 4.26 Per capita passenger-km of public transport in selected world cities

Source: Hayashi et al. (2004), as of UITP (2001)

In 2003, the Malaysian Railway Limited (*KTMB*) through a 17-year business growth plan provided its *Komuter* users ease to get access to numerous shopping complexes and recreational centres via system integration at Bank Negara and Bandar Tasik Selatan stations (Ampang/Sri Petaling line) and at the KL Sentral Station (Kelana Jaya line). In 2004, the *KTM Komuter* at Mid-Valley was the fourth station to have a direct link to a shopping complex. It strategically served the biggest shopping mall in the heart of KLMA and Asia, namely the Mid-Valley Mega Mall (Malaysian Strategic Research Centre, 2006). The design of its station design was disabled-friendly. It was equipped with massive parking lots and provided park and ride schemes. The Kepong Sentral Station, the 42nd. *Komuter* station adopted a similar design concept to that of the Mid-Valley. It was located at the north of the existing Kepong Station.

The Rawang-Rasa *Komuter* line opened to the public on April 20, 2007 (BERNAMA, April 21, 2007). In conjunction with Visit Malaysia 2007, *KTMB* introduced a special Tourist Pass for *KTM Komuter* travellers. The Tourist Pass was designated for a-24 hour unlimited travel to any destination within the network. A RM4.6-billion *KTMB Komuter* service project spanning 180km from Rawang to Ipoh started its operation in 2008 (BERNAMA, July 13, 2007). This double track Rawang-Ipoh was prepared for a high-speed upgrade (BERNAMA, September 5, 2008). It was also extended to Kuala Kubu Bharu in the same year. *KTMB* also extended the existing Klang Valley Commuter Network to Batu Caves. Upon completion, residence in the Selayang/Gombak municipality would benefit from a high capacity railway service that would also serve as an alternative means for road transport (The Star, November 8, 2006). This much-awaited Sentul-Batu Caves extension was to be completed by May 2009 (The Star, November 18, 2006).

However, the decline in four rail services in 2007 was very much related to the ineffectiveness of national campaigns on public transport awareness and usage by the government, in addition to low emphasis to public transport usage in both the Eighth and the Ninth Malaysia Plans. Furthermore, the influence of the world fuel price on car fuel subsidies greatly impacted on the continuing high propensity of car ownership and use.

4.7 ROAD TRAFFIC CONGESTION, ACCIDENTS AND ENVIRONMENTAL POLLUTION

Although Surabaya, Kuala Lumpur, and Bangkok ranked top in terms of growth in motorcycle ownership between 1980 and 1990, it was Kuala Lumpur and Bangkok that was ranked among the highest in the overall vehicle ownership growth rate (car plus motorcycle) during the same period (Marcotullio and Lee, 2003). The rapid growth of urban modernization and economic motorization affected the environment in KL. Marcotullio and Lee (2003) cited that KL and Bangkok were mainly exposed to air pollution and congestion problems. Studies by (Morikawa et al. 2001; 2003) further outlined that traffic congestion, frequent traffic accidents and air pollution in KLMA were crucial issues, which had been given national priority.

4.7.1 Road Traffic Congestion

From the mid 1980s, numerous mega infrastructure projects went into operation and were expected to generate high vehicular trips within the KLMA by 40%. In 1995, motorised private modes made up 69% of the mode split of all trips in KL (Townsend, 2003). Marcotullio and Lee (2003) also agreed that private mobility was higher than public transport supply in KL metropolis. It was clearly visible that while both public and private transport sector were expanding, the private transport sector was growing at a much faster rate, i.e., more than 5 times. With the ever-increasing reliance on car usage, serious operational problems affected traffic on most radial roads in the city centre of KL badly. The traffic experienced the space mean speed of less than 10 kph during peak hours. Road public transport also faced the same problem where its average travel speed was positively affected

(Topp, 1999, Leong, 2004). City public transport-related ills such as failure in route planning (Hilmi, 2003) and connectivity (Román and Martín, 2011), expensive as well as inefficient services (Kuala Lumpur City Hall, 2005a) continued on these radial roads.

Takatsu (2003) and Mak (2007) argued that low public transport modal share resulted in even higher demand on road infrastructure and devastating central traffic congestion (Figures 4.11 and 4.14) as well as accidents (Figures 4.30, 4.31, and 4.32). In the early 1990s the federal government decided to build more expressways and highways in Klang Valley because of the increasing size and population of the Klang Valley. Other reasons were development of new townships and industrial estates, and the massive traffic jams along Federal Highway (Figure 4.27). Therefore, Klang Valley was famous for its expressways' length per person i.e., 68 metres per 1000 persons and spatial urban density was relatively much higher than any other Asian city in the sample and in the developed countries i.e., 58 persons per hectare for data in 1997 (Bunnell et al., 2002, Marcotullio and Lee, 2003, Barter et al., 2003, Barter, 2004). Corresponding passenger cars and motorcycles per thousand persons were 209 and 175, respectively. Motorcycle passenger km per capita reflected by the motorcycles per thousand persons was the highest i.e., 1,365 passengers per capita. Another example was that, the modal split for person trips at the Middle Ring Road (MRR) 1 using private transport (car, taxi and motorcycle) was 54.3% in 1985, 64.1% in 1997 and 61.1% in 2005 (Jamilah, 2003).

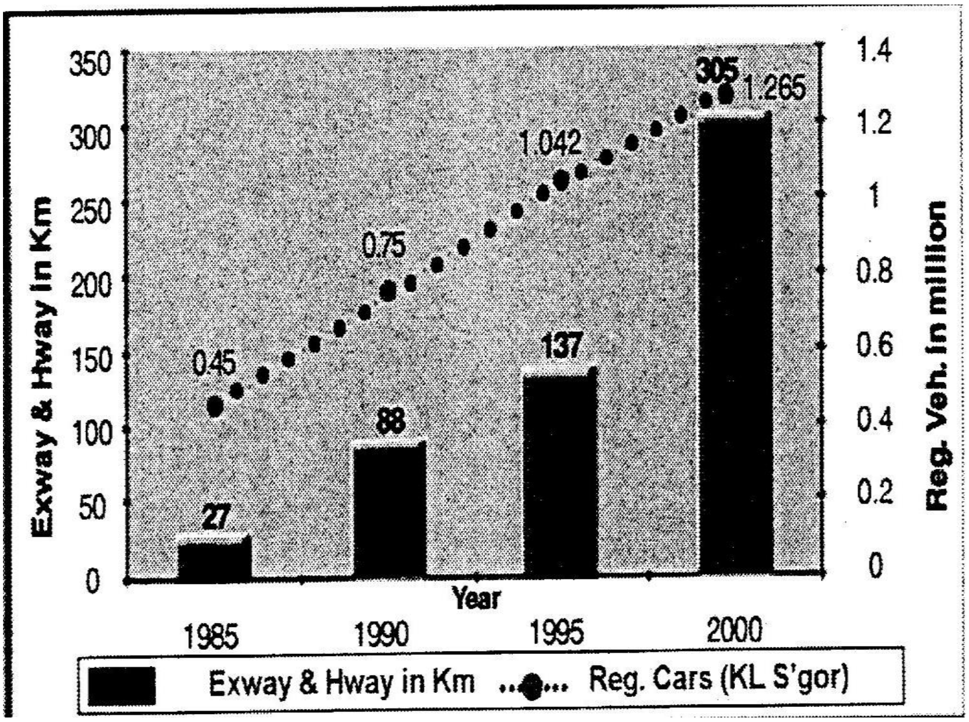


Figure 4.27 Total Length of Expressway and Highway, Total Registered Vehicles in Klang Valley and its conurbations (KVC) vs Time (Year), 1985-2000

Source: Japan International Cooperation Agency (2005)

Muhammad Akram (2007) stressed that the urban Malaysian expressway had limited access because it was fundamentally designed for high-speed through movements. At the other extreme, the limited ability to increase the supply of physical resources and services on urban Malaysian expressways in KL and Selangor by the road authorities may contribute to a critical traffic flow condition thus, reducing the average travel speed repetitively (Muhammad Akram, 2007). In this matter, road users in those areas became familiar with the normal phenomena of urban congestion on most urban Malaysian expressways. Christopher (2002) agreed with this statement where it was not an exception on local city roads today.

4.7.2 The Never-Ending Woes of Road Traffic Accidents in Kuala Lumpur

Road accidents are a huge economic and health problem facing Malaysia. Worldwide Deaths per million passenger kilometres travelled for Malaysia were 170 for motorbikes, 12 for cars, but only 1 for planes and trains (Malaysian Nuclear Society, 2008). Each year over 6000 people are killed (foreword by Prime Minister of Malaysia in the Malaysia Road Safety Action Plan 2004). By 2020, road deaths and injuries are predicted to become a leading contributor to the global burden of disease and injury (Murray and Lopez, 1996, Murray and Lopez, 1998). With reference to Radin Umar (2004), road traffic accidents have been declared as the number one killer in the local scenario, continuing to burden the national economy (Figure 4.28). Road traffic accidents have now become a major concern in Malaysia with on average of some 10 lives being lost on the road daily and over 30 during festive seasons (Royal Malaysia Police, 2007, Mustafa, 2005). In this matter, 5% of fatal accidents occurred as a consequence of the Road Safety Campaign called 'Ops Sikap IV and V 2007'.

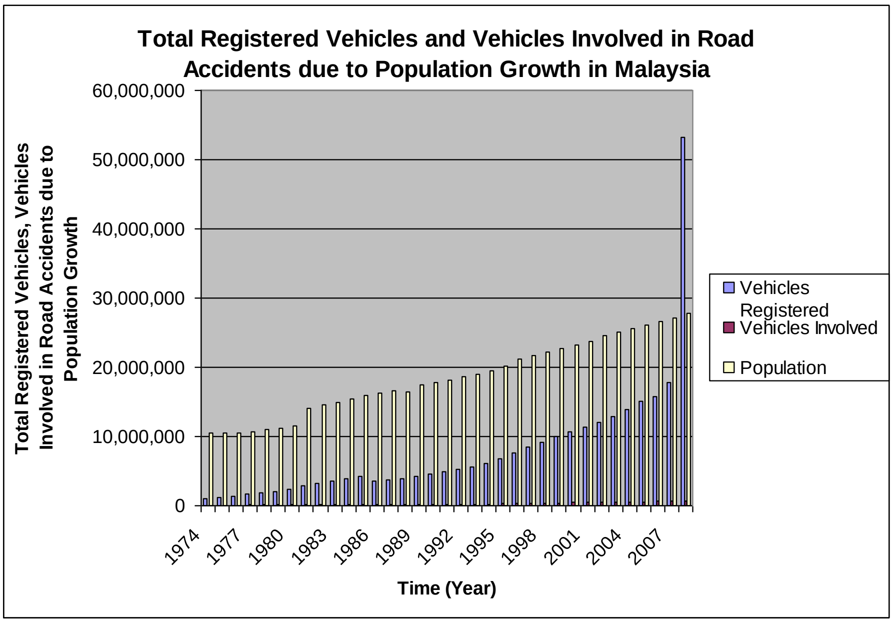


Figure 4.28 Total Registered Vehicles and Vehicles Involved in Road Accidents due to Population Growth in Malaysia

Sources: (Royal Malaysia Police (2008); the Malaysian Institute of Road Safety Research (2009); the Ministry of Transport, Malaysia (2009); Malaysian Road Safety Council (2009); Mustafa (2005))

Figures 4.11 and 4.28 suggest that the increase in road accidents is in line with the rapid growth in population, and developments in the economy, industrialization and motorization sectors. While private vehicles such as passenger cars and motorcycles have greatly helped to improve the mobility and accessibility needs of KLresidents, one should worry about the uncontrolled rising trends of private vehicle ownership in association with road accidents. Figure 4.28 indicates that both the total number of registered vehicles and the actual number of registered vehicles involved in road accidents was about 3.4 from 1992 to 2007, and it increased by roughly three times more from 2007 to 2008. The increase is very alarming where it represents more than half of the population in 2008 and the growth is twice of the population for 2009 probably because of an increase in earning capacity.

From Figure 4.11, it can be seen that in 2002 about 2.55 million registered vehicles plied KL roads on weekdays intersecting FTKL's population of 1.47 million. Meanwhile, the average number of vehicles entering FTKL was estimated at 740,000 daily.

The main causes of road accidents in KL are (1) speeding, 32.8%, (2) reckless driving, 28.2%, and (3) careless overtaking, 15.1%. From the statistics reported by the Malaysian Institute of Road Safety Research (2008), it is obvious that drivers' behaviour is the major cause of road accidents, which contributed to 76.1% of all the causes of road accidents. Other factors are tailgating (driving too closely behind another vehicle), 3.8% and road conditions, 3.0%.

KL, as a main metropolitan area in the heart of West Malaysia, was the second state that had accidents from 36,191 in 1997 to 38,100 in 2001. Even though it was among the smallest states in Malaysia, these figures were among the highest. Figure 4.29 confirmed that KL accident records accounted for half of the total road accidents in 1997 and more than one third of the 98,000 accidents in 2001 in Malaysia. Between 1990 and 1996, the number of reported passenger car accidents in KL increased by 92.9% from 19,365 to 33,375 as shown in Figure 4.30. Jamilah and Amin (2007) further reported that 52% of the total number of fatalities in KL were caused by motorcycles, 30% private cars, 10% lorries and vans, 3% buses, 2% taxis, and 3% pedestrians, respectively. Figures 4.31 and 4.32 prove that buses and taxis caused minimum accidents in KL and Selangor between 1997 and 2008. Table 4.3 recorded train incidents and accidents of not more than 30 cases for fifteen years of operation. Syahriah et al. (2013) reported that there were some three incidents and/or accidents involving *KTMB* Intercity trains between 2004 and 2006 due to shared track system with the *KTM Komuter*. However, KL was among the top 20 world cities with the highest number of fatal road accidents with an average of 148 deaths per one million population as recorded in 2005.

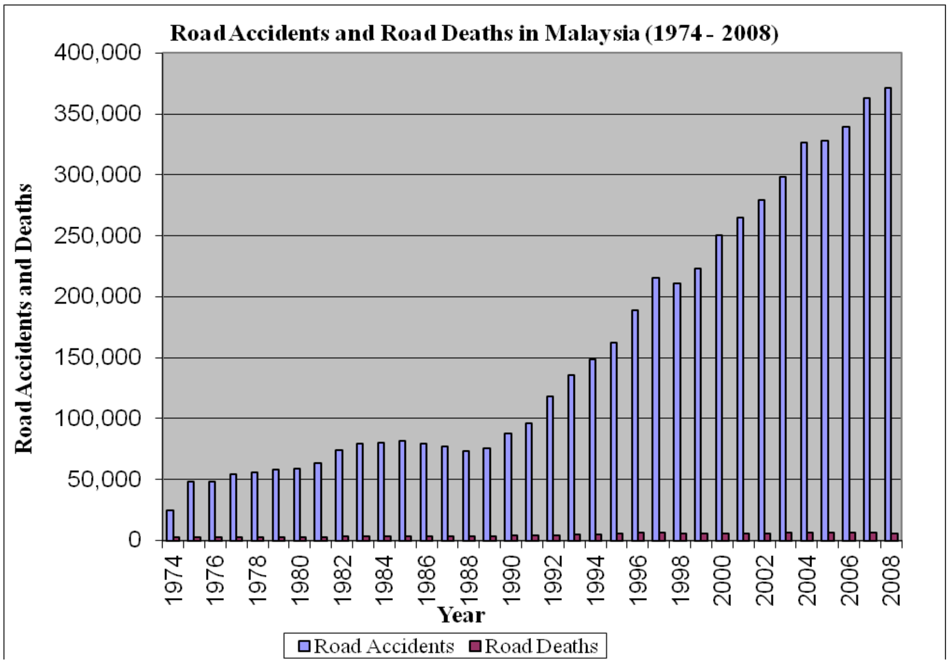


Figure 4.29 Road Accidents and Road Deaths in Malaysia, (1974-2008)

Sources: (Royal Malaysia Police (2008); the Malaysian Institute of Road Safety Research (2009); the Ministry of Transport, Malaysia (2009); Malaysian Road Safety Council (2009); Mustafa (2005); Radin Umar (2004))

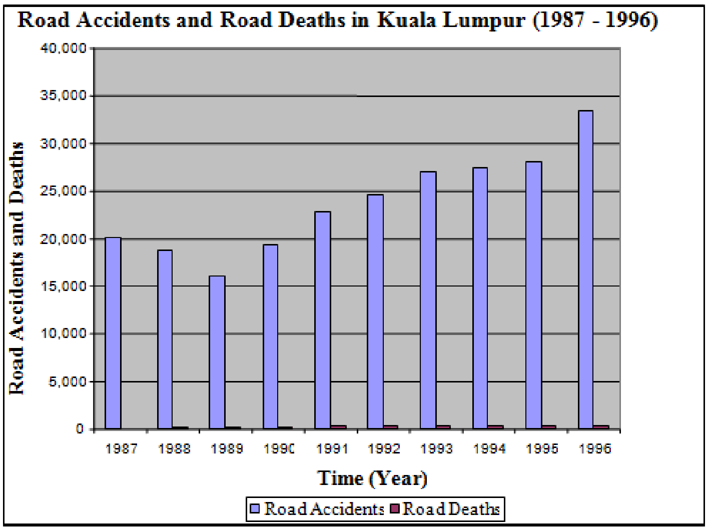


Figure 4.30 Road Accidents and Road Deaths in Kuala Lumpur, (1987-1996)

Source: Jamilah and Amin (2007)

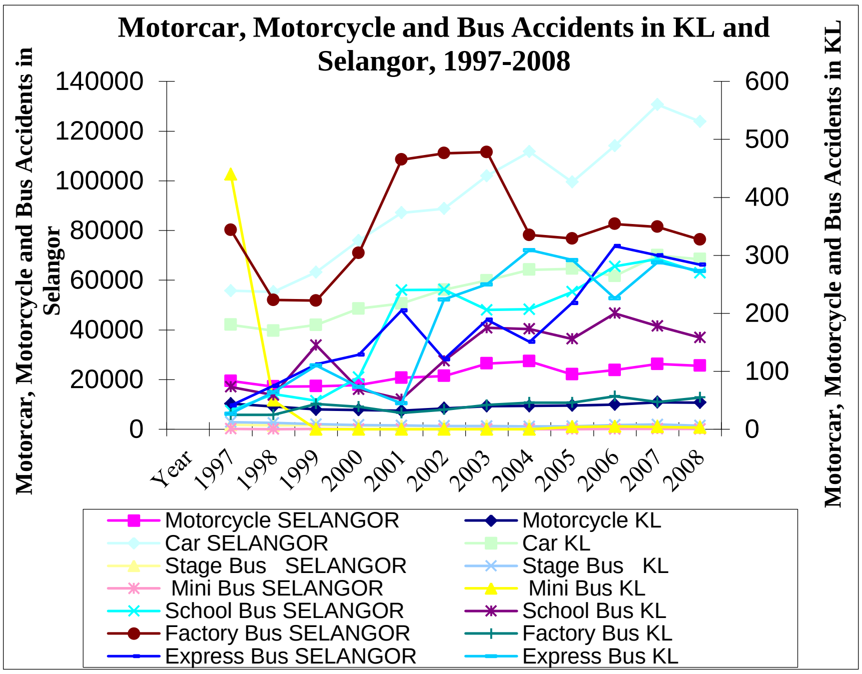


Figure 4.31 Motorcar, Motorcycle and Bus Accidents in Kuala Lumpur and Selangor, (1997-2008)

Source: Statistics Department of the Traffic Branch, Bukit Aman, Royal Malaysia Police (2009)

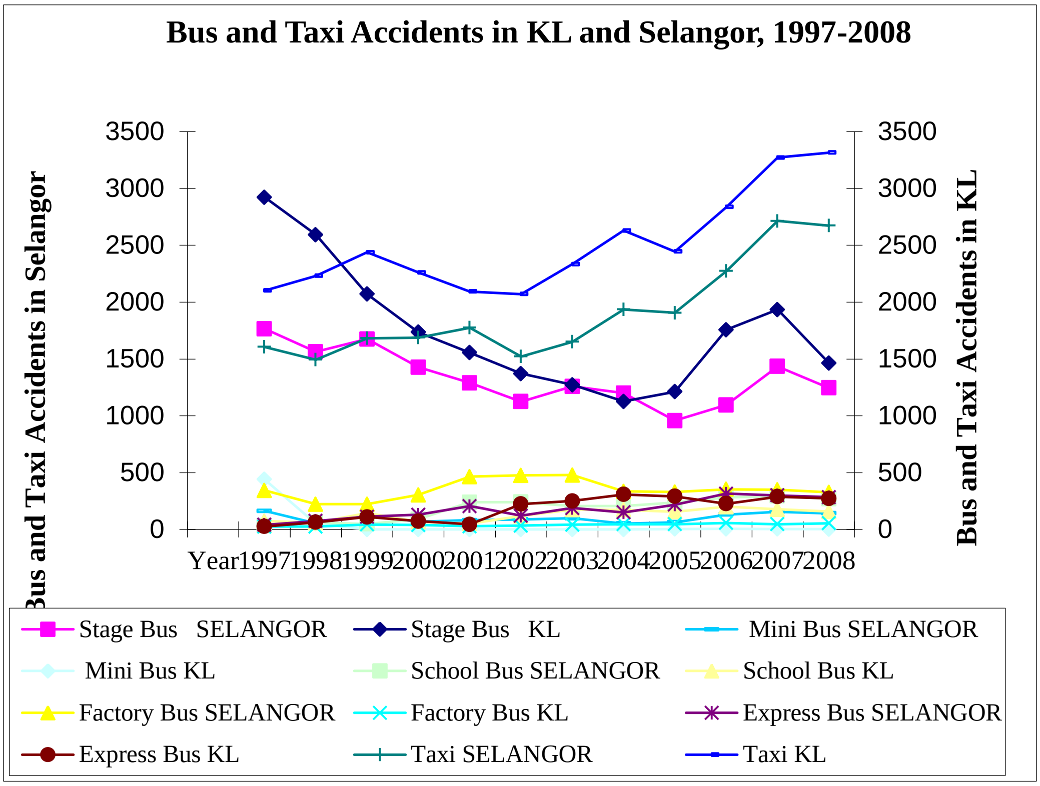


Figure 4.32 Bus and Taxi Accidents in Kuala Lumpur and Selangor, (1997-2008)

Source: Statistics Department of the Traffic Branch, Bukit Aman, Royal Malaysia Police (2009)

Table 4.3 Train and Rail Rapid Transit Incidents and Accidents in KLCUR

Train and Rail Rapid Transit Incidents and Accidents	**Ampang/Sri Petaling LRT Line**	**Kelana Jaya LRT Line**	**KL Monorail**	***KTM Komuter***	**KLIA Ekspres**	**KLIA Transit**
Year						
1995						
1996						
1997						
1998						
1999				≤ 10 incidents and accidents		
2000						
2001						
2002			16/08/2002			
2003						
2004			04/2004	3/03/2004		
2005			22/01/2005			
2006	27/10/2006	24/07/2006 24/08/2006 06/10/2006 12/12/2006				
2007				2/03/2007 25/05/2007		
2008	24/09/2008			27/02/2008		
2009						

Sources: http://www.economicexpert.com/a/Kuala:Lumpur:Monorail.html, http://www.skyscrapercity.com/showthread.php?t=171984, http://www.economicexpert.com/a/Kuala:Lumpur:Putra:Light:Rail:Transit.htm, http://en.wikipedia.org/wiki/Kelana_Jaya_Line#Criticisms, http://en.wikipedia.org/wiki/Ampang_Line#Accidents, http://thestar.com.my/news/story.asp?file=/2008/9/24/nation/20080924191742&sec=nation, http://dryadsong.com/forum/cache/temp/chiqasbo.html,

http://thestar.com.my/news/story.asp?file=/2006/10/28/nation/15849450&sec=nation&focus=1, and

http://en.wikipedia.org/wiki/KTM_Komuter#Incidents_and_accidents.

4.7.3 Evidence for Environmental Pollution

In KL it was estimated that 2.80 million vehicles emitted about 3700 tons of suspended microparticulate matter (PM_{10}) in 1989 (Pendakur, 1995). Rafia et al. (2003) further confirmed that PM_{10} was the result of the KL air quality study, of which it increased by 4-fold in the Klang Valley.

Potter and Skinner (2000) highlighted the findings of the World Health Organisation that was vehicle emissions as the major source of carbon dioxide recorded high casualties than road accidents. Similarly, the air pollution in KL was undesirable resulting in severe ‘haze’ from saturated motorized traffic emissions from 70-75% from the late 1990s to 82% in 1996 based on findings provided by the Department of the Environment, Malaysia (1996) (Rafia et al., 2003; Barter (2000); Barter (2004)). Khoo and Ong (2015) also reported that vehicle emissions were approximately 82% in the Klang Valley based on the Department of the Environment, Malaysia (2011). Air pollution accelerated bad health conditions due to minimal enforcement on private vehicle inspections and controls on transport emissions (Takatsu, 2003). Diseases like asthma, acute respiratory infections, and conjunctivitis dominated major hospitals in KL during August-September 1997 (Rafia et al. 2003). The estimated health effects for KL and Selangor were high because both states recorded an average PM_{10} of 170.60 and 131.22 $\mu g/m^3$, respectively. Its values considerably affected visibility and caused increased respiratory diseases like sinus, asthma, conjunctivitis, cough and hacking (Jamilah and Amin, 2007). The haze limited visibility to less than 500 m and produced suspended particles of up to 500 g/m^3 i.e., five times the “unhealthy” level (Rafia et al. 2003). “Unhealthy” or an Air Pollution Index (API) of 101-200 was recorded by the Air Pollutant Index Management System (APIMS) in the Klang Valley in 2004 (newsgroups.derkeiler.com, 2005). The dominant pollutant was the ground-level Ozone, O_3 (Asian Development Bank and the Clean Air Initiative for Asian Cities, 2006). The API 101-200 termed mild aggravation of symptoms among high risk groups (i.e., those with heart or lung diseases). On August 11, 2005, Kuala Selangor and Port Klang experienced an API above 500 indicating an emergency situation which described the level of pollution as being very unhealthy to hazardous (newsgroups.derkeiler.com, 2005).

4.8 RAIL TRANSPORT SYSTEM AS AN ALTERNATIVE TO CAR AND BUS USAGE

Tremendous economic growth stimulated the multiplication of car ownership and traffic congestion (Homem de Almeida Correia et al., 2013) in most of the cities in Federal Territories, Selangor and Johore states in accordance with motorized vehicles registered in Malaysia by state in 2011 (Rozmi et al., 2013). The Government took positive steps to alleviate these escalating problems with the encouragement of the Rail Transport System-Rapid Rail Transit System usage (Cunningham et al., 2000; Ahern and Anandarajah, 2008; Xie et al., 2009; Suria, 2012; Frost et al., 2012; Jiang et al., 2012; Rozmi et al., 2013; Tsai et al., 2013; Syahriah et al., 2013). Such rail systems will form the central feature of an integrated public transport network (Figure 4.33), combining feeder buses to offer an efficient alternative to the current limitations of road capacity and car trips. Besides, it can potentially reduce the consumption of energy (Hossain, 2007; Chou and Kim, 2009; Toš et al., 2011; Ke et al., 2012), improve existing or projected quality of air (Cunningham et al., 2000; Lai and Chen, 2011; Frost et al., 2012), mobility (Tsai et al., 2013, Eboli and Mazzulla, 2012, Gallo et al., 2011) and urban life (Cao, 2013); decrease levels of noise pollution mainly from the cars and motorcycles (Lai and Chen, 2011), fight climate change (Román and Martín, 2011; Frost et al., 2012) and, likewise, transform financial resources (Parkinson and Fisher, 1996, Douglass, 2000, Morikawa et al., 2001, Morikawa et al., 2003, Jamilah and Amin, 2007). McDonald (2003) and McDonald et al. (2003) concluded that rail-travelling was six times safer than car-travelling. The Association of Train Operating Companies (2000) as cited by McDonald et al. (2003) mentioned that rail travel was more than sixteen times safer than road travel and could provide future revenues.

In parallel, May and Roberts (1995) outlined some possible cost-effective options to alleviate British car traffic in urban areas since 1993 including bus priority scheme, park-and-ride scheme, upgraded rail system incorporating high parking constraints, pedestrianisation and other appropriate means of travel demand management (TDM). Givoni and Rietveld (2007) and Román and Martín (2011) also underlined that a rail journey must be made accessible enough in order to be chosen as an attractive travel alternative to car and bus. This rail journey should be alternatively supported by public transport as main access-egress modes illustrating empirical evidence by the Dutch railways between 1988 and 1998 where free public transport for students was highlighted to be the possible side effect of improving public transport to/from railway stations to mainly lure those car users to get to/from it. As a corollary, Román and Martín (2011) asserted that accessibility to Madrid-Atocha (HST stations) in the Madrid-Barcelona corridor and airports can determine the decision of modal choice. Residence’s relocation also potentially attracted car users to use public transport (Gärling and Axhausen, 2003). Givoni and Rietveld supplemented that data for the UK, Germany and the Netherlands interestingly demonstrated that the car was not the first choice of access mode to get to the home end (origin) station, thus explaining the insignificant effect of the availability of car (or car ownership) on the whole home base rail journey. Yet, Kingham et al. (2001) investigated on the personal travel in the UK and found that the alternative non-car modes' travel was likely to dominate during the occasional trips.

'Rail was found to be more energy efficient than road and air (Chou and Kim, 2009; Toš et al., 2011; Feng, 2011; Ke et al., 2012). A rail network required less land to build than a road network (Chou and Kim, 2009; Tsai et al., 2013). Tsai et al. (2013) further reported that one passenger riding a train with maximum capacity uses only one-sixth the energy and generates one-ninth the carbon dioxide compared with a car travel while only half the energy and a quarter of the carbon dioxide are used compared to bus travel. Moreover, Chou and Kim (2009) highlight that an high speed rail (HSR) produces only about 0.625% of a car's carbon monoxide/carbon dioxide emissions. Frost et al. (2012) added that a growing electric supply would result in decreased carbon footprint for the electrified routes of the rail sector from 20% to 35%. CO_2 emissions per passenger kilometres were found to be 100 times less on passenger rail than in a private car. A double track railway carries the same volume of traffic as a six-lane motorway, but is safer and relatively less damaging to the environment' (McDonald et al., 2003). Besides, public transportation systems provide the most efficient means for moving large number of people in compact cities. In addition to this high-density feature, Huang and Niu (2012) introduced passenger trains in particular which are more time efficient (or time-saving as claimed by Feng (2011)) with restricted coach size due to fixed railway track. In another research by Feng (2011), the setting of the optimized target speed of the China Railway High-speed (CRH) train together with traction energy-efficient and time-efficient would positively impact the service quality and operation cost. Román and Martín (2011) also stressed on the superiority of the High Speed Train (HST) in Spain to reduce impacts of congestion, pollution, noise, road accidents and global warming. In fact Cunningham et al. (2000), Gärling and Axhausen (2003) and Chien et al. (2010) say rail transit is a priority for commuters in their daily travel because it plays an important role in relieving congestion in big metropolitan areas. Subway systems or urban commuter rail systems per se also have similar function in more than one hundred cities worldwide according to Chun et al. (2011). These situations should be provided by facilities, services, comfort, convenience, accessible, safe, affordable, more commuter-friendly for children and the elderly, and travel information characterized by high quality of services (Muhammad Faishal, 2003). Aside from these services, this service attribute can also consider computerized technology to optimize the rising-demand subway systems with respect to additional ridership and faster frequency (Chun et al., 2011). High level and quality of public transport services is very crucial and significant for retaining existing passengers, making these passengers use the rail system more often and attracting new ones from other modes of transport (Eboli and Mazzulla, 2012, Rozmi et al., 2013, Beirão and Sarsfield Cabral, 2007, Lai and Chen, 2011, Givoni and Rietveld, 2007, Chou and Kim, 2009, Irfan et al., 2012). For example, Rozmi et al. (2013) state that three major groups such as workers, students and tourists expect the best public transport services. Light rail transit, LRT is often far much better than buses in respect to frequency (Giuliano (2004) as cited by Cao (2013)). Similarly, some travellers would prefer to ride the LRT because of its higher quality of services than buses (Ben-Akiva and Morikawa, 2002) as also mentioned in Cao (2013). Moreover, Chou and Kim (2009) and Chien et al. (2010) pointed out that an efficient rail transit was expected to provide competitive services to a diverse public's preference (Lai and Chen, 2011) even if under the constraints of limited fleet size and excessive demand.

There is low train and rail rapid transit incident and accident statistics in KLCUR. For instance, Table 2.3 recorded train and rail rapid transit incidents and accidents of not more than 30 cases for fifteen years of operation.

The findings from Beirão and Sarsfield Cabral's (2007) analysis on light rail versus bus indicated that light rail was mainly perceived by car users as more reliable, comfortable, frequent, faster and spacious than bus service. The other finding was that intangible attributes included feeling less stressful and tired, having new, attractive, funny, convenient and easy to use transportation. Furthermore, car users demonstrated that light rail was an 'ideal service' because they experienced the most attractive light rail travel describing it to be silent, fast, efficient, advantageous, funny, and traffic free and lesser waiting times. Hence, they favoured the service quality of light rail in comparison to bus services, especially in terms of reliability and frequency. The above results were also confirmed by Steg (2005) as mentioned in Pronello and Camusso (2011), proposing features such as being more comfortable, flexible, and attractive thus becoming significant in defining more sustainable public transport to lure car users. Jiang et al. (2012) further stated that the key rail system performance characteristics that found to be overperforming the bus rapid transit (BRT) were reliability, comfort and speed.

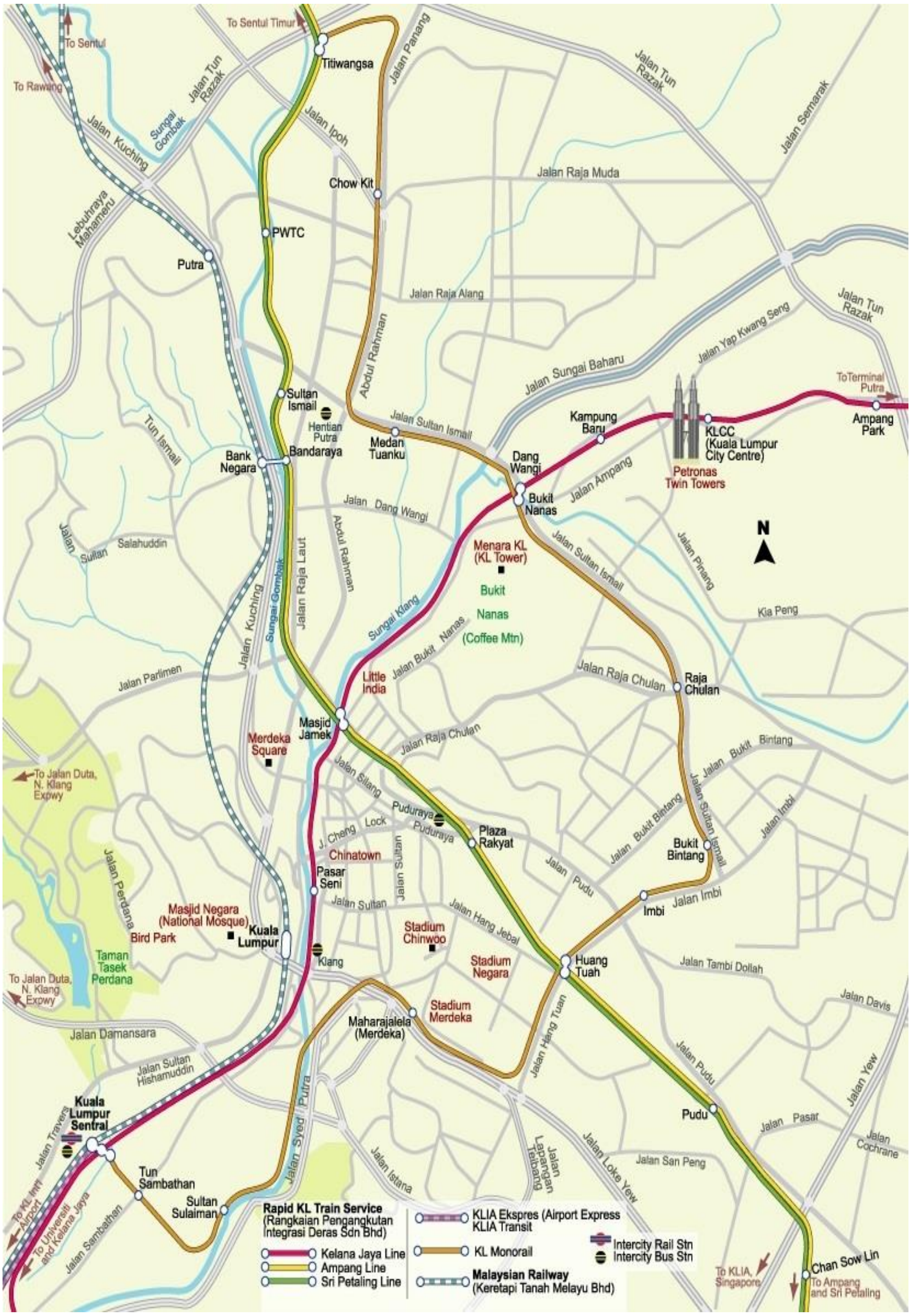


Figure 4.33 KL Rail System

Source: http://www.malaysiasite.nl/klsentraleng.htm

4.9 HISTORY OF RAIL IN KUALA LUMPUR

The history of rail transport dates back nearly 150 years in Malaysia. In the 19th. century, railways served most of the public transportation demand. The first single railway track was built in 1885 linking the tin mining town, Taiping to Port Weld. It was run by the Perak State Railways. In 1913, the single rail connection linked Padang Besar in Perlis to Singapore. The Gemas – Tumpat single rail connection up to Hadyaai in southern Thailand was completed in 1930. These were the earliest intercity services of the Malayan Railways. In the beginning, all rail services were managed separately according to each Malayan state. British colonials later decided to streamline all rail administration by implementing the Malayan Railway Ordinance in 1948. For that reason, the Federated Malay State Railways (F.M.S.R.) became the Malayan Railway Administration which upon corporatization, was re-named *KTM Berhad* or the Malayan Railways Limited. The Malayan Rail Transport System underwent a tremendous change, from the first steam locomotive in 1885 to diesel engines in 1958. *KTM Berhad* then was corporatised on August 1, 1992. *KTM Berhad* or *KTMB* or the Malaysian Railway currently operates as a private organisation, responsible for its own revenue and operations. 1961 marked the end of the European's directive of the *KTMB* of which *KTMB* was not entitled to any profits in 1961 and thereafter. Overall, *KTM* serviced the colonial era for seventy two years and contributed in passenger and freight services to the federal territory of Malaysia for twenty eight years. As a conclusion, the railway system was constructed in Malaya on the basis of local economic control policy, thereby only giving priority to the states that yielded lucrative returns.

Another type of urban rail transit was known as the Advanced Rapid Transit (ART) or the Light Rail Transit Systems (LRT). Formerly it was referred to as PUTRA-LRT and STAR-LRT. Now both are known as Rapid KL lines. PUTRA-LRT operated in 1998 and was fully automated. It started from the Depot in Subang and ended at Terminal Putra in Gombak, which accounted for 29 km in length with a total of 24 pick up and drop off stations. The first operation commenced on September 1, 1998 between the Lembah Subang Depot and the Pasar Seni station and Section 2 was indicated by stations ranging from Pasar Seni to Terminal Putra in June 1999. The Ekspres Rail Link (ERL) was initially planned to be operational for the Kuala Lumpur International Airport (KLIA's) opening in June 1998. The cost of project was about RM2.8 bn (USD730mn). The first trains were run in 2002, some four years behind the actual schedule. ERL services comprise KLIA Ekspres and KLIA Transit. The KLIA Ekspres is a high-speed rail between Kuala Lumpur City Air Terminal (KLCAT) in Kuala Lumpur Sentral (KLS) and KLIA. Specifically, KLCAT is a hub for air travellers, which is located at both ends of the station's concourse level. In-town check-out facility in KLCAT for arriving passengers operated by 2010. KLIA Ekspres was the first aerotrain or airport train in Malaysia. KLIA Transit offers commuter rail services at a frequency of 30 minutes. This unique combination of convenience of travel services and operations is known worldwide as Air-Rail Intermodality.

As far as integration is concerned, ERLs intersect with the heavy rail system i.e. *KTM Komuter*, *KTM* Intercity, Rapid KL lines and KL Monorail at KLSS while KLIA Transit intersects with the Sri Petaling line and *KTM* Komuter (Rawang – Seremban line) at Bandar Tasik Selatan. Rapid KL lines are currently known as the Kelana Jaya line and Ampang/Sri Petaling line). The opening of the KL Monorail on August 31st., 2003 completed the first phase of the Integrated Kuala Lumpur Transit System (IKLTS) with a total of 98 stations, covering KLMA. However, the KL Monorail was fully operated in 2004, forming about 182 km of rail network within the Klang Valley (Mohammad Ali et al., 2006).

Every morning and evening during peak hours, the six systems carry their loads of passengers leaving the stations and terminals, making it the greatest travel option within the city centre and from the city centre (KLS) to KLIA.

4.10 RAIL OPERATIONS IN KUALA LUMPUR CORE URBAN REGION (KLCUR)

Rail services became significant since the operations of a commuter train in 1995 and two LRT systems in 1998, i.e., the Kelana Jaya line and the Ampang/Sri Petaling line. In terms of service coverage areas within the KLCUR, all rail systems are 'urban' except the *KTM Komuter* that falls under the 'suburban' category. A few in literature define urban rail or LRT as a metro system.

Rail public transport has a limited passenger demand because of its fixed route. That is why feeder bus services are very much required to increase the coverage areas, thereby easing accessibility to particular stops, stations, and terminals, and thus enhancing the financial performance with respect to ridership and revenue (Gwilliam, 1999; Hilmi, 2003; Jamilah, 1995, 1997, 2003; Zulina, 2003; Tan, 2008). As no fully integrated common ticketing scheme can be used for all systems, commuters had to buy new tickets when transferring. So, the train/railway operators (including the bus operators of Park May and Intrakota) accepted the integrated common automated fare collection, applying the contactless Touch'n Go (TnG) (stored value fare) smart card and new Malaysian Identity Card (IC), MyKad as *e-purse* from July 1, 2005 (*KTMB*) and March 1, 2008 (RapidKL buses and rail lines), and since the end of 2002 (in November), respectively. The Kuala Lumpur Sentral Station (KLSS) was strategically designed to be an excellent example of an integrated transport terminal. The KLSS provided advanced facilities as early as April 16, 2001. Large waiting areas and ample luggage space; availability of interchange stations with different types of rail and similar facilities to those at an airport were some of its features.

With rising industrial motorization and its related problems and automation as well, the government has strategically structured a massive scheme of public transport infrastructure development to expand KL rail transport network, *per se*. Although some areas like Bandar Damansara, Cheras and Bukit Jalil are not covered, the network will form the basis for future extensions and station additions as illustrated in Figure 4.34. The expansion of the existing ART cars and the proposal for an extension of network will also see the Kelana Jaya line grow in line with KL's population and urban regeneration. The Government introduced the Economic Transformation Programme (ETP) in June 2010 to increase economy and to achieve a high income status by 2020 (Suria, 2012). Mass Rapid Transit (MRT) construction will be one of the mega projects under the twelve National Key Economic Areas (NKEA) of the Tenth Malaysia Plan (2011 – 2015) that was planned to be implemented in 2012. These projects would develop "Greater KL" at a cost of RM36.6 billion and the MRT Co. would be in-charge of the projects. This MRT construction would be part of a new public transport infrastructure in the Klang

Valley and that it is known as the Klang Valley MRT to minimize road traffic congestions in KL, to ensure that the public gains additional facilities along with mobility convenience to extend the inadequate existing rail network system (Suria, 2012; Chuen et al., 2014) and to promote a mode shift from private vehicles to public transport (Khoo and Ong, 2015). Six million passengers in the Klang Valley would benefit from this project whilst ten million passengers would be expected to benefit from it in 2020 (Tenth Malaysia Plan, 2010; Chuen et al., 2014).

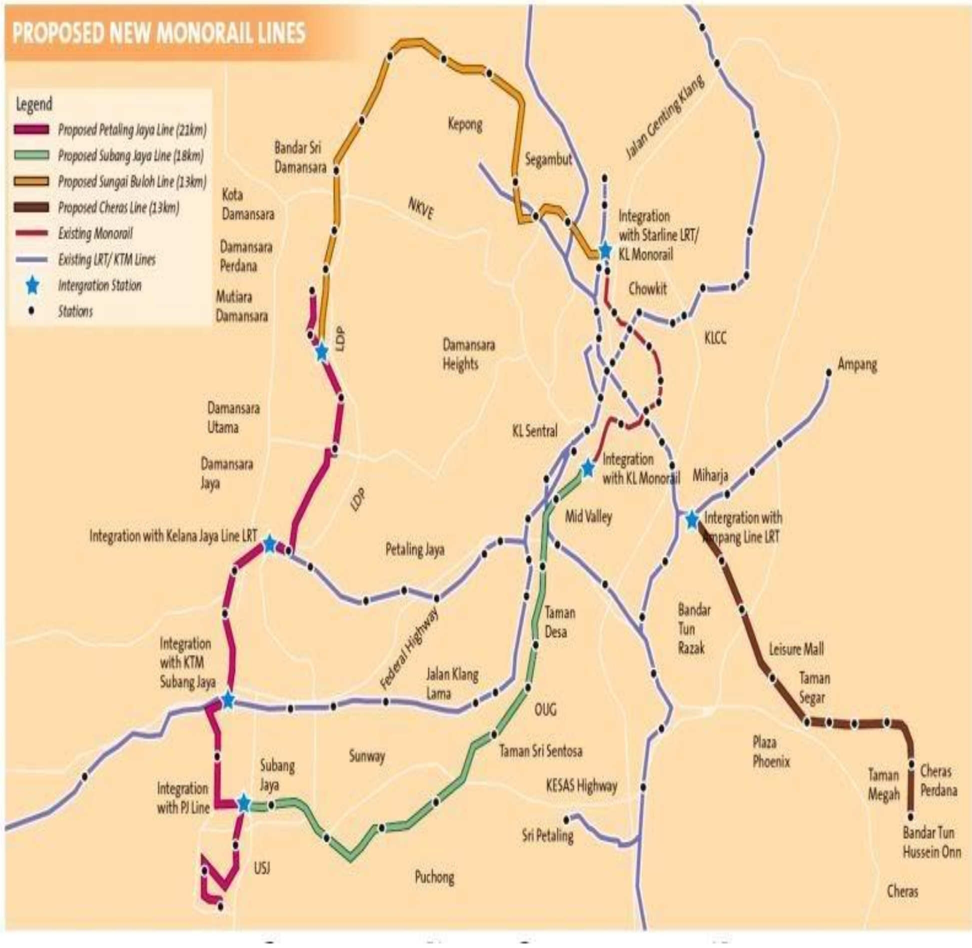


Figure 4.34 The Proposed KL Monorail Lines

Source: John (2009) originally posted in http://www.skyscrapercity.com/showthread.php?p=12274526

In 2010, the number of daily trips by rail services with a total of seven main routes in Klang Valley were 560,000 trips (7.73%), covering 224.6 kilometres. The target scenario by 2020 is 22.58% (Chuen et al., 2014).

4.10.1 The Operations of the Kelana Jaya Line

The Kelana Jaya line (Figures 4.35, 4.36 and 4.37) mainly serves as the preferred choice of travel mode for city workers and visitors in and out of the constantly congested city (Christopher, 2002). It has 1 at-grade station and 18 elevated stations while the remaining five are underground tracks of 5 km and 24 km on a viaduct at 1.1 km intervals along its 29 km length. The typical 68 m long platform is equipped with emergency buttons. It has 220 maintenance staff to manage up to 160 operations. It integrates with the Ampang/Sri Petaling line at the Masjid Jamek station.

Total travel time is 45 minutes, cutting short car-travel by at least an hour. Travelling across the city could take about 30 minutes, but the average is 10 minutes within the city centre. It currently operates with 35 of its two-car units, fully air-conditioned, travelling at an initial average speed of 38 to 40 kph (a maximum speed of 80 kph). It is the world's second longest, articulated Mark II of the ART and the longest self-powered metro in Asia. It operates from 06:00 to 23:40, 7 days a week thereby operating for approximately 18 hours a day. Peak hours are from 7am to 9am and 4pm to 7pm from Mondays to Fridays, and on Saturday from 7am to 9am and 12 to 2pm. Frequency of service during peak hours is 90 seconds-3 minutes for an initial capacity of 10,000 passengers per hour, per direction. Frequency of off-peak service is 5-10 minutes. Trains leave approximately every three minutes during peak hours and about eight minutes apart during non-peak hours. It also provides a feeder bus service for its commuters within a 3-km radius and there are parking bays at selected stations.

The Kelana Jaya line uses an automatic fare collector (AFC) with ticket vending machines (TVMs), automatic barrier and magnetic-strip tickets (smart cards). Tickets are also available at the counters. Table 2.4 shows the fares of the Kelana Jaya line. The fare for the full stretch is RM4.50. Passengers are entitled to a 50% discount off the regular fare. Commuters can enjoy a discount of 20% during peak hours. On Sundays and public holidays, commuters can enjoy a 30% discount throughout the day.

Table 4.4 Fares along LRT Routes

LINE (S)		FARES
Kelana Jaya Line (Line E)		Single fare RM0.70 - RM2.50 depending on distance
Ampang and Sri Petaling Lines (Lines C and D)		Single fare RM0.70 - RM2.80 depending on distance
Monthly pass	LRT and buses	RM 125.00
	LRT only	RM 90.00

Source: http://www.railserve.com/jump/jump.cgi?ID=15385
(Beautiful Photos of LRTs & KL Monorail)

Figure 4.35 The Kelana Jaya Line – Existing Advanced Rapid Transit (ART) cars in KL

Source: Glickenstein (2007)

Figure 4.36 Train at the Kelana Jaya Line

Source:http://upload.wikimedia.org/wikipedia/commons/d/d9/Yosri042005PuteraLRT.JPG

Figure 4.37 The interior of the Kelana Jaya Line

Source:
http://commons.wikimedia.org/wiki/File:Kelana_Jaya_Line_(train_interior).jpg

4.10.2 The Operations of Ampang/Sri Petaling Line

The Ampang/Sri Petaling line (Figures 4.38 and 4.39) consists of at-grade and elevated corridors servicing the KLMA. A 27-km route covers the elevated track as it enters the central business district (CBD) and the suburbs that comprise Ampang (State Railway corridors-upgrading) to the east, a southern link to the housing zones and commercial centres in Sri Petaling, the Complexes of National Sports and recreational park in Bukit Jalil, and a northern extension to the 'Golden Triangle' of KL.

Travel time across the city to the suburban areas could take at least twenty minutes. Trains run at a maximum speed of 70 kph whereas its commercial speed is

35 kph. The trains are fully air-conditioned. The LRT will initially operate every five minutes from 07:00 to 20:00 everyday. Its detailed operations are from 06:00 to 23:50 on weekdays for every 3 minutes during peak hours and from 06:00 to 23:00 on Sundays with a frequency of 7-8 minutes during off-peak times. With a 792-passenger capacity, it can carry 16,000 passengers per hour per single trip in each direction. Table 4.4 shows the fares of the Ampang/Sri Petaling line.

Figure 4.38 Ampang/Sri Petaling Line, formerly known as STAR LRT; A view at Bukit Jalil Station.

Figure 4.39 Ampang/Sri Petaling Line (frontal view)

Sources: http://www.urbanrail.net/as/kual/kuala-lumpur.htm and http://www.railserve.com/jump/jump.cgi?ID=15385

4.10.3 The Operations of KL Monorail

The KL Monorail (Figures 4.40 and 4.41) is fast becoming the main public transportation system especially to those working around the KL Golden Triangle (BERNAMA, June 29, 2006). It serves mainly to cater to inner-city short trips. The RM1.18 billion KL Monorail privatization project is also aimed at easing movement within KL. It also takes passengers to most of the popular spots in the city centre. It has made shopping and business appointment in KL more pleasant and less time consuming (Figure 4.34) (Christopher, 2002). The 8.6 km long, dual guideway, straddle-beam parallel elevated tracks monorail system begins its route from the Pekeliling Bus Terminal at Jalan Tun Razak in the north, passing through the Golden Triangle to KLSS in Brickfields. It has pneumatic tyres hugging the sides of a concrete beam for movement along the top of the beam. Fully elevated with 12 stations - each between 600 to 1000 m apart - the KL Monorail is capable of handling up to 18,000 passengers per hour per direction. It operates up to 2 minutes headway between trains. The total travel time is 19 minutes. KL Monorail runs from 06:00 to 24:00. At present the trains have only two carriages and twelve trains.

The KL Monorail fares can be seen from Table 4.5 below.

Table 4.5 Fares of KL Monorail Route

LINE (S)	FARES
KL Monorail	RM1.20 - RM2.50 depending on distance

Source: http://www.railserve.com/jump/jump.cgi?ID=15385
(Beautiful Photos of LRTs & KL Monorail)

Figure 4.40 Looking north from Bukit Bintang Station. Unlike the monorails of Japan, long spans are not made of steel. Note the long distance between these two pylons over this intersection span.

Source: http://www.monorails.org/tMspages/KLspecial08.html

Figure 4.41 The center seat also serves as a cover of the load-bearing wheels.

Source: http://www.monorails.org/tMspages/KLspecial08.html

Figure 4.42 The Roman Coliseum is featured on this Malaysia Airline-sponsored train. The coupler allows train link-ups for extended trains or in rare circumstances, the towing of inoperable trains.

Source: http://www.monorails.org/tMspages/KLspecial08.html

In early 2004, the trains were quite small and was thus overcrowded at peak times. The station platforms were much longer than the trains, enabling the redesigning of the size of trains.

Good physical integration is very important for multimodal transport efficiency. KL Monorail's integration of stations with Ampang/Sri Petaling line are connected at Titiwangsa and Hang Tuah. The Kelana Jaya lines are physically integrated at Bukit Nanas (P Ramlee) and the KL Sentral (KLS), ERLs are physically integrated at KLS, and *KTM* Komuter is physically connected at KLS.

4.10.4 Ekspres Rail Link (ERL) Services

ERL operations from mid-2002 to end-2007 went about with several air users alternatively checking-in at the KL City Air Terminal (KLCAT). The Emirates Airlines joined in the luggage check-in services at KLCAT (Jamilah, 2003). This was followed by Malaysia Airlines, Cathay Pacific and Royal Brunei Airlines. From July 23, 2007 onwards, passengers flying on all 43 airlines serving the Kuala Lumpur International Airport (KLIA) were able to check in their luggage at KLCAT should the airline offer city check-in services. The ERLs are shown in Figures 4.43 and 4.44. The KLIA Ekspres is a non-stop rail system that plies between KLCAT at KLS and KLIA, to and from in just 28 minutes. This 57.6-kilometre city-airport connection operates from both terminals 7-days a week with a 15-minute interval during peak hours and a 20-minute interval during non-peak hours (09:00–16:00, 22:00–24:00). Its maximum operating speed is 160 kph whereas its individual cruising speed is 176 kph. With these speeds, KLIA Ekspres is the fastest train in South East Asia. The operation starts as early as 05:00 am and the last train provides services as late as 13:00. KLIA Ekspres has a seating capacity of 156 passengers per its four-car train set with no standees at all, including handicapped space with 4-flip up seats. The number of train sets is 8 four-car trains which are fully air-conditioned and 4-car trains with a headway of 15 minutes for ERL. The ERL-CRS is capable of simultaneously handling a 8-car ERL train at a frequency of 10 minutes while the 8-car CRS train travels at a frequency of 20 minutes both ways.

The single fare of KLIA Ekspres is RM35.00 for an adult passenger and each child is charged RM15.00. KLIA Ekspres return fare is RM70.00 for an adult passenger while children from two to twelve years old double the one-way fare of RM30.00. Infant passengers of less than 2 years are not charged.

KLIA Transit provides a commuter rail service (CRS) (Figure 4.44). A 37-minute journey from KLS to KLIA and vice versa will stop at three intermediate stations. These stations are Bandar Tasik Selatan, Putrajaya/Cyberjaya and Salak Tinggi. Bandar Tasik Selatan station serves as a transit point, where passengers can either transfer to the *KTM* Komuter, Ampang/Sri Petaling line or ERLs. The first train departs at 05:33 from KLS to KLIA for 19 hours daily and the operation ends at 24:03. In contrary, the first departure is at 05:52 from KLIA while the last train from KLIA is at 13:00. KLIA Transit runs 7-days a week, every 30 minutes during peak periods and one-hour during off-peak times. It is equipped with 144 seats per its four-car train set with 396 standees under regular operating conditions. It can allow as many as 540 passengers plus standees at one time. Fares are charged based on distance travelled. This can be seen in Table 4.6.

Figure 4.43 KLIA Ekspres has been specially designed to cater to most air travellers' needs

Source:

http://upload.wikimedia.org/wikipedia/commons/d/df/KLIAekspres_SalakSelatan.jpg

Figure 4.44 KLIA Transit is a high-speed transit service between two terminals, but with quick stops at three key townships along the MSC.

Source: http://nurrul-iman.blogspot.com/2009/01/klia-transit-train.html

Table 4.6 One-Way Fares of KLIA Transit

One-Way Fares					
Station	KLS	Bandar Tasik Selatan	Putrajaya/Cyberjaya	Salak Tinggi	KLIA
KLS		*4.20* 2.00	*9.50* 4.50	*12.50* 6.00	*35.00* 15.00
Bandar Tasik Selatan	*4.20* 2.00		*5.30* 2.50	*8.30* 4.00	*26.50* 13.00
Putrajaya/ Cyberjaya	*9.50* 4.50	*5.30* 2.50		*3.00* 1.50	*6.20* 3.00
Salak Tinggi	*12.50* 6.00	*8.30* 4.00	*3.00* 1.50		*3.20* 1.60
KLIA	*35.00* 15.00	*26.50* 13.00	*6.20* 3.00	*3.20* 1.60	

Source: http://malaysiabudgethotel.com/transportation/trains/klia-express.html

Note: *Adult Fare*

Child Fare

Senior citizens are also encouraged to take the KLIA Transit, but the one-way fare is much lower rather than normal fare, that is, RM20.00 for both KLS-KLIA and Bandar Tasik Selatan-KLIA. A senior citizen can be defined as a Malaysian of ages 55 years and above with proof of ownership to a Malaysian IC. KLIA Transit Return Packages are also available, but the distance for its travel is limited to only KLS-KLIA and Bandar Tasik Selatan-KLIA. The details are as shown in Table 4.7 below.

Table 4.7 KLIA Transit Return Packages

<table>
<tr><th colspan="4">KLIA Transit Return Packages</th></tr>
<tr><th>Package</th><th>Sector</th><th>Adult Fare</th><th>Child Fare</th></tr>
<tr><td>Meeter & Sender Return (return within 6 hours)</td><td rowspan="3">KLS–KLIA
Bandar Tasik Selatan-KLIA</td><td>50</td><td>20</td></tr>
<tr><td>2-Adult Return</td><td colspan="2">98</td></tr>
<tr><td>Family Return (2 Adults & 2 Children)</td><td colspan="2">100</td></tr>
<tr><td rowspan="3">Visit Putrajaya Special</td><td>KLS – Putrajaya/Cyberjaya</td><td>10</td><td>5</td></tr>
<tr><td>Bandar Tasik Selatan –Putrajaya/Cyberjaya</td><td>7</td><td>3</td></tr>
<tr><td>KLIA-Putrajaya/Cyberjaya</td><td>10</td><td>5</td></tr>
</table>

Source: http://malaysiabudgethotel.com/transportation/trains/klia-express.html

4.10.5 *KTM Komuter* Services

KTM Komuter started revenue services as the first fully air-conditioned electric rail in Malaysia between KL and Rawang (Figure 4.45). These Electric Multiple Units (EMUs) run on a 25kV AC system covering Rawang to Seremban and Batu Caves to Port Klang. According to Tukis and Nizamuddin (2012), *KTM Komuter* is a popular rail transport among commuters without private cars who work in KL and want to avoid road congestion. The *KTM Komuter* network has 46 stations, including the KLSS. The meter-gauge track allows trains to run at a speed of up to 120 kph. The EMUs have an automatic train protection (ATP) system, which monitors the train's speed and which allows for the application of brakes automatically if the driver fails to respond. This safety feature permits a one-man operation.

KTM Komuter's 215 daily services start at 05:30 and stop at 24:00. Services run at headway of 15 minutes during the morning rush from 05:30 to 09:30, and this frequency is also maintained during the evening peak hours from 15:30 to 20:00. The service frequency is reduced to one train every 30 minutes at other times.

KTM Komuter uses AFC with TVMs, automatic gates and magnetic-strip tickets. In addition to the normal single and return tickets, regular users can buy 12- and 24-trip tickets at a discount rate of 20% and a monthly season ticket at a discount rate of 33%. A pass tour ticket entitles the holder to unlimited travel on the network during weekdays after 09:00 am. It costs RM6.00 (RM1.00=US$0.26). Similarly, ticket day pass for weekends and public holidays cost only RM10.00. It is worthwhile because stations of *KTM Komuter* have a major source of leisure, sight-seeing, and shopping sites plus other personal- and casual-trips as well to offer to their travellers (Tukis and Nizamuddin, 2012). *KTM Komuter* also used the prepaid Touch'n Go smart card in 2003, which was also accepted by Rapid KL buses (stage and feeder) and LRT, and at toll highways.

KTM Komuter fares are charged based on the origin and destination of the trip. Two fare structures are remained from 2003 to date, that are, single journey for adults and children/elderly people/disabled people which can be seen on the *KTM Komuter* website, that is, fare tables.

Figure 4.45 A class 83 *KTM Komuter* electric train (Hyundai Marubeni/Mitsubishi Electric, South Korea/Japan) (Designation: EMU 35) at the Bank Negara *Komuter* Station, KL.

Source:* *http://en.wikipedia.org/wiki/File:Class_83_KTM_Komuter_train,_Kuala_Lumpur.jpg

4.11 CONCLUSIONS

In this chapter, the research background is described thoroughly and the problem statements are further refined. Similar to many big cities in the world, to some extent KL offers efficient public transports to enable mobility. Public transport in KL had evolved in tandem with the development of the national economy. KL is fortunate to have been supplied with a simple and user-friendly first elevated electric bus rapid transit (BRT) Sunway Line since 2nd. June 2015 and rail services since 1995. However, public transport in KL is currently insufficient to cater to overwhelming demand. It is timely for public transport in KL to optimize its quantity and quality of service in an economical manner to improve public transport planning, design, operations and management within a setting of sustainable mobility. So, there is always a need for operations research and development (R and D) in capacity and demand modelling within any public transport agency.

CHAPTER 5 : METHODOLOGICAL APPROACH

This chapter provides details on the methodological approach and the types of data collected. The methodological approach is further elaborated under the following subheadings: overview of detailed study approach, sampling, data collection, processing and analysis. An explicit explanation on the types of data collected is covered under the subheadings entitled data requirements, data availability and data gaps. Data variables, data on trip characteristics, methods of data collection and survey instruments are listed under data requirements. Data availability highlights the sources of both primary and secondary data. Meanwhile, data gaps briefly reveal the weaknesses, limitations and difficulties encountered in the research.

5.1 INTRODUCTION

Findings from previous research by Rahaman and Rahaman (2009), Low (1994), Geetika and Nandan (2010), Annamalah et al. (2011), Prasad and Shekhar (2010b), Cavana et al. (2007), Drea and Hanna (2000), Tripp and Drea (2002), Ugurlu et al. (2011), Lai and Wu (2011), Transportation Research Board (1999; 2013), Wahida (1997), Cunningham et al. (2000), Fazlina et al. (2010), Fu and Xin (2007), Bharathi (2010), Eboli and Mazzulla (2007), Wyckoff (2001), Duncan (2010), Vuchic (2005, 2007), Too and Earl (2010), Oña et al. (2012), Sliwa and O'Kane (2011) and Kim (2011), Tseng (2012), Liu and He (2010), Irfan et al. (2012), Tukis and Nizamuddin (2012), Rohana et al. (2012), Redman et al. (2013)

and Jain et al. (2014) provide the methodological assistance to conduct the current research that aims to explore and identify the variables that best define high quality *KTM Komuter* service and to develop empirical models known as KOMIQUAL models to determine which of these variables have the greatest impact on *KTM Komuter* service quality for a network of routes or corridors. The KOMIQUAL models appear in the form of the AMOS graphics for the final structural models of the First Order Confirmatory Factor Analysis (CFA) and the Second Order CFA assisted in enhancing the researcher's understanding of the significance of the findings (research contribution). They are referred to as KOMIQUAL due to the types of commuter train models i.e. KOMI (the existing *KTM Komuter* which comprises three models, such as KOMI1 or set 81 which originated from Austria, KOMI2 or set 82 which originated from South Africa and KOMI3 or set 83 that originated from South Korea) and QUAL referring to the word quality. These models served as a guide in defining high *KTM Komuter* service quality in order to optimise service provision and to be customer-oriented (Too and Earl, 2010; Lai and Chen, 2011; Filippi et al., 2013).

The application of the triangulation method of which more than one method of data collection was applicable in that both qualitative and quantitative methods were carried out together with other measurements (Kamruzzaman and Hine, 2011). According to Kamruzzaman and Hine (2011), each method uniquely complements each other when combined because each method has values. Therefore, a means of triangulation of findings in a large set of responses can ensure almost accurate data (Hine et al., 2012). This research was initiated with qualitative methods which involved a series of representations including the participants' observations, interviews and long conversations with both the *KTMB* staff and *KTM Komuter* passengers and field notes, photography shootings as well as document analysis. This was followed by quantitative methods which employed surveys and questionnaires, an analytical technique that sought to understand behaviour by using complex mathematical and statistical modelling, measurement and research, and secondary data. Field surveys for an urban single corridor (route) level i.e. Port Klang-KL Sentral-Sentul line of the *KTM Komuter* involved observational studies, counts, on-site measurements and direct interviews including long conversations (passenger surveys - questionnaire forms). Passenger or user or commuter train surveys were carried out on-board (ride checks), at stops, at terminals, and at passages/corridors of the stations (point and automated checks). Here, passenger surveys included an origin and destination (O-D) survey, attitudinal surveys and passenger boarding and alighting surveys and counts. *KTM Komuter* Train Volume Studies or Counts at main terminal stations such as Sentul and Pelabuhan Kelang rail stations were also conducted. Service quality often depends upon usage in congested or crowded conditions. There is a need to measure crowding levels at sites too. Consequently, photography shootings were also executed on both the train coaches and station platforms at certain railway stations to depict the impact of overcrowding from morning peak to off-peak periods during weekdays and weekends.

Such passenger train surveys should provide detailed information on passenger volumes on transit units (TUs) over various line sections and their variations in time, train loadings, maximum TU load and the corresponding section, allocation of revenue and investigation on service quality. In other words, the average rail ridership by train can be estimated via practical sampling strategies to obtain representative O-D, Attitudinal and OnBoard riders' profiles and needs for rail market purpose (DOT, 1996). More accurate directional information like city and out of city destinations could be determined through the O-D survey.

The Passenger Boarding and Alighting surveys were conducted on board the train for city travel (from Pelabuhan Kelang to Sentul) and outbound travel (from Sentul to Pelabuhan Kelang). They included train boardings, alightings and capacities at each station. In addition to that, the results for Passenger Boarding and Alighting surveys incorporated demand (volume and distance) and fare levels (affordability aspect) together with the indicators of operation efficiency such as the operating cost per passenger kilometres, the operating cost per boarding or for every passenger trip and farebox ratios from 2008 to 2012 for varied time periods i.e., peak times, inter-peak and off peak times. Fare levels were measured by calculating the mean fare per total passenger kilometres and the mean fare per boarding. The demand level provided the key performance indicators such as the number of passenger trips, the mean trip length, the mean boardings per kilometre, the mean passenger volume per kilometre, the maximum load section (MLS) and the maximum loads at certain rail stops or stations. The *KTM Komuter* Train Counts resulted in the average number of TU per day per line, total train kilometres, total train capacity provided and utilization ratios for *KTM Komuter* from 2008 to 2012 for various time periods i.e., for early birds, travellers who travelled at peak hours in the morning, afternoon, evening and during off peak times. Early release and latecomers were also considered.

5.2 OVERVIEW OF THE DETAILED STUDY APPROACH

Figure 5.1 shows a summary of the detailed study design process. The flow chart begins with the formulation of research objectives. This stage was positively executed only after the researcher managed to identify the research problems. The next stage was to form related hypotheses. This was followed by establishing several relevant definitions from the research topic and title. This step will aid the researcher in defining correct or relevant terms in finding research materials for literature reviews. The research materials can be from any form of references especially those from journal articles, conference papers and proceedings, government documents, standards (specifications), reports, books, book sections, electronic books, datasets, personal communications, newspaper articles, etc.

A series of desk studies were carried out to communicate on the data requirements and their availability from the train or railway operators. This was done by obtaining much co-operation from the officers of the Department of Railways, the Ministry of Transport, Malaysia and *KTMB*. The researcher met with the representatives of the *KTMB* through a series of meetings prior to field work. These meetings were very helpful and important as those representatives provided their experiences and knowledge of the sites to identify anomalies in the service provision. Accordingly, such meetings and even the existing local literature provided some guidances to design an appropriate timetable. Following this, a timetable for the field work was finalised. The field work was planned to be undertaken at target areas like busy stations and in rather typically crowded coaches and stations. To this end, the most crowded coach was selected for a reliable method base. This was to ensure consistency in the data collection method and to increase situation's generalizability (Nor Diana, 2012) as the physical structures of coaches varied not only between the types of commuter trains, but also within individual rail operations (Hirsch and Thompson, 2011). In addition, this research did not target special event crowding. Amongst special events in the research area were school holidays, festive seasons, commercial- and social-based exhibitions, and sporting events. This research also did not intend to examine parking facilities, and staff courtesy and customer services because the researcher did not notice the importance of these parameters in the data triangulation.

The sampling practical method to find an adequate sample size for surveys was determined through several basic calculations and the use of tables guided by Ceder (2007) that resulted in the minimum sample size of 320 to achieve a high confidence level (probability) of 95% which means a confidence interval of 5% for a population of 6.187 million capita in the Klang Valley (Chuen et al., 2014). Confidence interval is also called a margin of error whereas the 95% confidence level means one is 95% certain. It was also checked by a web-based calculator to automatically calculate sample size. Probability sampling is a simple random method. This sampling method relates to the number of survey questionnaire forms for both the Origin-Destination surveys and the Attitudinal surveys. The minimum number of sample is calculated by a web-based calculator was 318 in which this meant large samples and more robust inferences (Iacono et al., 2010).

The subsequent step was to carry out a visual appraisal survey as many times as possible in order to get used to the sites, to take some photographs, to identify the referenced points for detailed field survey and target users. A visual appraisal survey is a survey of familiarization to the survey site locations. It is part of field work. Field notes were immediately prepared after each phase of time variation (i.e. seven time phases) observations and the emerging trends in the data were identified. For a sound sensible data, these trends were further explored during the next set of observations. The researcher also kept notes about her own experiences as a passenger on *KTM Komuters* and likewise, gained an insight into the typical *KTM Komuter's* crowding problems during day-to-day travel. Turning to field work task, this was fully performed by the researcher to ensure the consistency and accuracy of empirical data collection method and to avoid bias associated with many observers.

The ensuing course of action was to design and prepare questionnaires. The O-D survey questionnaire form was adapted from DOT (1996), *KTMB* (2004), Vuchic (2005), Adibah (2007), Ceder (2007), Jain et al. (2014) and other rail O-D surveys, including that in (Preston, 1987). The Attitudinal survey questionnaire form was adapted from DOT (1996), *KTMB* (2004), Vuchic (2005), Adibah (2007), Ceder (2007) and Jain et al. (2014). The designated questions would incorporate main considerations on the operational performance of the transit like transit flow and quality of services (characteristics that require the users' standpoint). The Transportation Research Board (2003) recommended that the transit flow characteristics be described by the average speed of the transit, the frequency of services, accessibility, the number of coaches, travel time, waiting time, the number of route choices; the number of stations, stops, transfers (Stopher, 1974) and terminals throughout the entire route network. The Board also stated that reliability, punctuality, comfort, convenience, safety, security, capacity, time information, environmental impact, origin and destination of the route, and trip purpose became parameters to define the LOS of the transit.

The transportation (travel behavioural) surveys included Origin-Destination (O-D) surveys, Attitudinal surveys, Passenger Boarding and Alighting surveys and counts, and Train Volume Study (Train counts) to identify the needs of the current users inclusive of some future travel information on the betterment of the performance of *KTM Komuter* in services and utilities that will later assist in the decision-making of Urban Rail Operations, Planning and Economics. Mobility measures are passengers' socio-demographic and trip characteristics and O-D surveys. Accessibility measures are ridership, trip frequency and person-metres/km travelled. Passengers' satisfaction measure is the scoring or ranking of perceived and experienced service attributes via Attitudinal or Opinion surveys. These surveys were conducted from February 2010 to 1st.March 2010. Such manual counts need to be conducted more frequently to capture seasonality and day-to-day variation. It also involved field work that ranged from observations, counts, measurements and interviews. It can be concluded that these methods of data collection yield reasonable results in cases in which the route structure is not overly complicated. The obtained data can be considered as revealed-preferences (RP) data since detailed passengers' preferences will be revealed through their choices describing their actual travel behaviour. Cooper and Schindler (2011) state that normally, a RP survey requires small sample size but the present study employed large sample size due to the fact that the conducted surveys involved human beings and relations. The RP surveys allowed researchers to characterise the typical *KTM Komuter* user and journey in the particular route of Port Klang-Sentul. This survey approach was found suitable for the present study because respondents will not have time to forget the characteristics of their current trips, thereby increasing the reliability and validity of responses (Cambridge Systematics, 1996, Syahriah et al., 2013). In addition to that, the surveys involved field and passenger observational studies, where the studies took place in the regular and normal environment of the passengers and the latter often requires interview techniques (Coolican, 2009) so that the researcher(s) can remember the passengers selected (Amiruddin et al., 2012).

In the data preparation and data reduction stage, data is to be entered manually in the IBM Statistical Package for the Social Sciences (SPSS) statistical analysis computer software version 20 following the SPSS format in order to prepare for a data file. In addition to that, Microsoft Excel is also used to store other raw data. The data must also go through data screening and cleaning processes in the IBM SPSS. These processes are necessary to check the data file for any errors (Pallant, 2010).

Data entry involved the data processing stage. Data processing started with preliminary data analysis which involved a detailed descriptive statistics analysis. Descriptive statistics and graphs can help greatly in the early stages of data processing. Data were further processed through exploratory data analysis. Exploratory data analysis is a process of carefully examining data prior to performing inferential statistical tests or submitting data to significance testing. Coolican (2009) stated that ‘the main aim of exploratory data analysis was to present data in visually meaningful ways while retaining as much as possible the original information and data.’

The data analysis and modelling incorporated statistical methods and economic optimization approach. Optimisation fit in the analysis and modelling of passenger-based data obtained through the Passenger Boarding and Alighting surveys. The stage of statistical methods is very important to develop a model i.e., path diagrams.

SPSS and SEM-AMOS are selected for data analysis and modelling because a minimum sample size for SPSS and SEM-AMOS is 20 and 250 respectively (Mohamed, 2014). The multivariate statistical technique of factor analysis is usually carried out for exploring the relationships between a set of variables. Then, data were critically reduced and analyzed using the exploratory factor analysis (EFA). Factors or variables and number of items were reduced significantly in the confirmatory factor stages of analysis. The confirmatory factor analysis (CFA) is within the scope of this research. Moreover, the evaluation of the final data (model) will exploit the CFA of the SEM method with Analysis of Moment Structures (AMOS) Graphics and programme because there is no dependent variable in the questions. This particular software is adopted because it is a computer programme to help in a SEM modelling the effects of service conditions. This analysis determines which factors (variables) and items are the most significant to impact the results and hence assist in the selection of the optimal setting or best solution of model development in the form of path diagrams. Once the travel behavioural analysis model has been evaluated, decision analysis in terms of operational planning is easy. The Economic Optimization approach involved the development of mathematical models or equations with the use of basic calculus and Microsoft Excel software. These simple rail line or network models can incorporate externalities into social cost functions, adapting the basic model derived from the work of Vickrey (1955) and Mohring (1972) and Jansson (1980). It will explicitly solve the issues concerning integration and coordination in public transport network *per se*.

Data evaluation is done by calculating relevant formulae in the spreadsheet of Microsoft Excel 2007. The results are then compared to the standard threshold values in the Analysis of Moment Structures (AMOS) software in order to check the reliability and validity of the data.

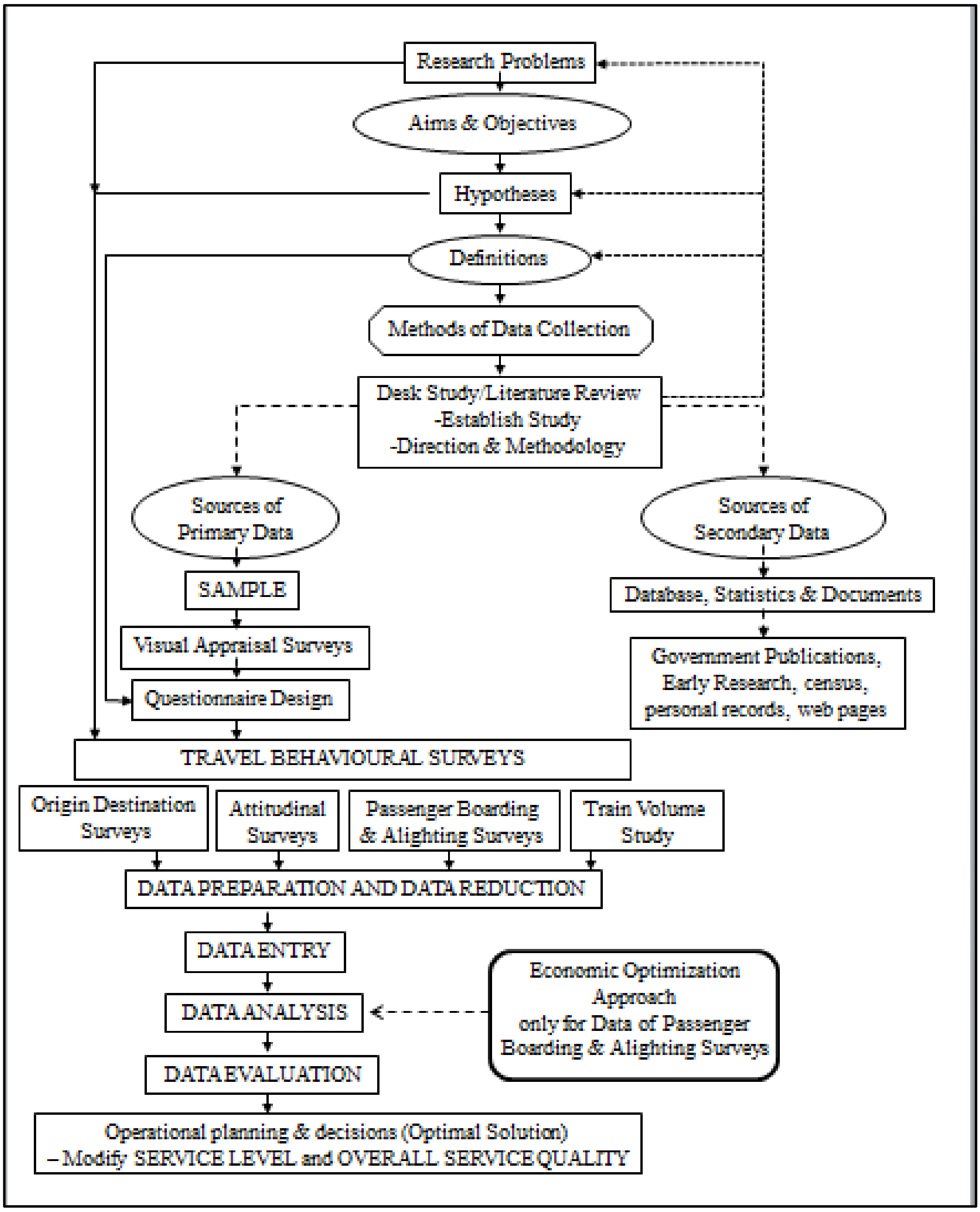


Figure 5.1 Summary of the Detailed Study Design Process

5.3 SAMPLING AND DATA COLLECTIONS

5.3.1 Questionnaire Format

The research was dependent on primary data and secondary data. The attitudinal surveys were conducted in February 2010 and on 1st. of March 2010 on a sample of 388 *KTM Komuter* passengers. The questionnaire was close-ended and guaranteed annonimity to measure customers' (passengers) service quality requirements of *KTMB* services. The questionnaire form for the Attitudinal surveys can be seen in Appendix A and it comprised the following structure. The questionnaire form was divided into four short sections. The first section consisted of introductory information. This introductory information contained the project title, the objectives of the project, number of forms, name of station, name of observer, day/date/time of survey, weather and direction of the train. The second section of questionnaire comprised question items that were used to evaluate the reason(s) for using the *KTM Komuter*. The third section of questionnaire gauged answers to assess passengers' perceived importance and performance (satisfaction level) towards 45 service quality features of the *KTM Komuter*. A five-point Likert-type scale, ranging from 1 (very poor) to 3 (fair) to 5 (very good), was used to measure the research variables in terms of a perception (Chowdhury et al., 2014). Part of this second section, also contained open-ended, brief questions used to access the passengers' suggestions or comments to improve the quality of services. The fourth section involved getting some background information on eight items, such as age group, gender, nationality, number of persons or people (over fifteen years of age) living in the household or family size, respondent's occupation, personal status, economic status (i.e. employment and monthly income).

The questionnaire form for the Origin-Destination surveys can be seen in Appendix B and it comprised the following structure. The questionnaire form was divided into three main sections that contained introductory information, commuting characteristics including the origin-destination, trip purposes, the services' and operation's attributes of the transit tested such as the source of *KTM Komuter* travel information, fare category, ticket type, methods of ticket payment (or the purchase of a ticket) and return mode of transport, and the last section was geared towards getting the general personal characteristics of the expected respondents. The introductory information covered the project title, the objectives of the project, number of forms, name of station, name of observer, day/date/time of survey, weather and direction of the train. Personal characteristics (user profile) are described by age group, gender, nationality, occupation, employment status, respondent's status, average monthly income as well as domain-specific individual characteristics such as main trip purpose, travel frequency, household size, number of private vehicles in household i.e. car ownership and car usage.

The questionnaire forms were prepared in two versions, in English and in the Malay Language.

5.3.2 Sampling Strategies

Sampling strategies were conducted from February 2010 to early April 2010. The first three weeks of January 2010 were fully utilised for extensive secondary data gathering from identified government agencies and several transportation and traffic consultants. Survey programmes were carried out from 2nd. February to 1st.

April 2010. Table 5.2 through Table 5.9 depict the details of the survey programmes.

Table 5.1 O-D surveys at KL, KLS, Shah Alam and Subang Jaya

O-D surveys				
KL station	KL Sentral station	Shah Alam station	Subang Jaya station	Shah Alam station
Tuesday 02/02/2010	Wednesday 03/02/2010	Thursday 04/02/2010	Friday 05/02/2010	Saturday 06/02/2010
0700-1000; 1000-1300; 1400-2200				

Table 5.2 O-D surveys & Attitudinal surveys at Bank Negara & Putra stations; Attitudinal surveys at KL, KLS, Shah Alam and Subang Jaya stations

Actual Surveys: O-D & A surveys	Attitudinal surveys			
Bank Negara & Putra stations	KL station	KL Sentral station	Shah Alam station	Subang Jaya station
Monday 08/02/2010	Tuesday 09/02/2010	Wednesday 10/02/2010	Thursday 11/02/2010	Friday 12/02/2010
0600-1000; 1000-1300; 1400-2200				

Table 5.3 O-D surveys at KLS, Shah Alam, Subang Jaya, KL, Putra and Bank Negara stations

O-D surveys								
CNY break: Poster-making	KL Sentral station	Shah Alam station	Subang Jaya & KL stations	Subang Jaya station		Putra station	Bank Negara station	Putra station
Tue 16/02/10	Wed 17/02/10	Thu 18/02/10	Fri 19/02/10	Sun 21/02/10	Fri 26/02/10	Mon 08/03/10	Mon 22/03/10	Fri 26/03/10
0600-1000; 1000-1300; 1400-2200								

Table 5.4 Attitudinal surveys at Bank Negara, KL, KLS, Shah Alam and Subang Jaya stations

Attitudinal surveys				
Bank Negara station	KL station	KL Sentral station	Shah Alam station	Subang Jaya station
Monday 22/02/2010	Tuesday 23/02/2010	Wednesday 24/02/2010	Thursday 25/02/2010	Monday 01/03/2010
0700-1000; 1000-1300; 1400-2200				

(cyan) travel behavioural patterns on the weekends

(red) Prophet Muhammad’s Birthday – National holiday

CNY Chinese New Year

Table 5.5 Passenger OnBoard Surveys from Port Klang to Sentul station

Passenger boarding-alighting countings		
from Port Klang station (Port Klang-Sentul direction)		
Tuesday 02/03/2010	Wednesday 03/03/2010	Thursday 04/03/2010
0530-1000; 1000-1200; 1400-2200		

Table 5.6 Passenger OnBoard Surveys from Sentul to Port Klang station

Passenger boarding-alighting countings		
from Sentul station (Sentul-Port Klang direction)		
Tuesday 09/03/2010	Wednesday 10/03/2010	Thursday 11/03/2010
0545-1000; 1000-1200; 1400-2200		

Table 5.7 Passenger OnBoard (through going) Surveys

Passenger on-board (through going) countings [a series of occupancy rate surveys or train capacity and levels of service, LOS studies]		
Port Klang-Sentul direction (from Port Klang station)		Sentul-Port Klang direction (from Sentul station)
Tuesday 23/03/2010	Wednesday 24/03/2010	Thursday 25/03/2010
0530-1000; 1000-1200; 1400-2200		0545-1000; 1000-1200; 1400-2200

Table 5.8 Train Volume Studies

Train Volume Studies	
Port Klang station	Sentul station
Tuesday (30/03/2010)	Thursday (1/04/2010)
0520-2422	0700-2405

5.3.3 Sampling Process and Methods of Data Collection

A combination of Stated and Derived Importance methods with random sampling was used to collect more responses and to increase generalizability (Tseng, 2012). The sample had to be random in order to ensure that it was representative of the population, which means that it had similar characteristics to the population. However, the random sampling method may be subject to careless application by researchers or field workers (observers). So, it is often practical to conduct non-probability sampling in order to obtain convenience samples in the description that follows (Cooper and Schindler, 2011). Data was collected from passengers who wished to board (in the vicinity of stations and platforms) and who were in the train coaches. In successfully conducting these rail user surveys and ensuring high quality data, face-to-face interviews were also carried at the passage (awaiting floor) very near to the rail track while passengers waited for incoming train and when they were inside the train for every origin-destination so that the response rate would be high (Daniels and Mulley, 2013) because the passengers were guided to answer questionnaires (Saodah, 2014). They were guided continuously to reduce duration of thinking, travel decision and trip process. Rail users were asked about their willingness to participate in the survey and if they agreed to join they were firstly interviewed. They were secondly asked to complete a questionnaire under the guidance of the data collectors. The interviews were structured and took 10 to 15 minutes on average. All answers reported by the respondents were carefully noted even though the respondents were hurried in providing their responses resulting from anxiety while waiting for arriving or departing trains at the stations or platforms. This had severe weaknesses. Passengers were likely to have poor knowledge of the attributes of travel options. Even worse, the answers they reported in a hurry and under duress may be biased to justify the choice they made. As a consequence such abundant consistent misreporting would cause serious bias in the estimated model (Small and Winston, 1999). The population studied in this research were all passengers who travelled on *KTMB* trains during the surveyed period. The respondents included all groups of people who used railway services. In exchange for completing the survey, the first 120 respondents were provided with a fridge magnet provided by *KTMB*. This fridge magnet is one of the *KTMB* souvenirs in the gift shop at *KTMB*. The sample was stratified into peak, off-peak and inter-peak users. The questionnaires were distributed to the respondents selected and they were briefed on the purpose of the research (Ceder, 2007). Respondents were asked about their socioeconomic characteristics namely their origin, destination, purpose of trips and their satisfaction level on the present service condition. To evaluate rail passenger service quality, the rail passengers were asked about 45 service attributes selected primarily through available literature review. This was a type of interview for the passengers and railway executives (staff). They were scrutinized for their ride experiences to their general well-being (Syahriah et al., 2008) and familiarity of rail services (Crockett et al., 2004, Daly et al., 2012). A scale from 1 to 5 would denote the satisfaction level from very poor to very good. Passengers were asked to grade their satisfaction level regarding their experience, perception, acceptance and attitude towards existing service conditions. Data was reviewed immediately after the surveys to observe unusual patterns and to assure accuracy.O-D surveys provided miscellaneous information and data on events in operations and fares such as methods of fare collection and types of fares; and, likewise, train-dispatching efficiency to convey useful information for transportation planning (Thériault and Rosiers, 2004) whilst Attitudinal surveys provided information on passenger attitudes such as passenger preferences with respect to schedules, riding comfort and other service parameters.

Passenger Boarding and Alighting survey is also called a passenger on-board survey (Pratelli and Brebbia, 2011) or a passenger counting survey (Stopher, 2000) or a passenger volume or capacity study. This survey was done involving manually recorded counts. The observer recorded the time period of count, the location, the date and day, weather conditions, actual arrival times, the type of train, colour of seats and, number and position of doors on one train coach at which a train stops for passengers boarding and alighting from only one rail car or train coach. The observer also counted the number of passengers boarding and alighting the train over an entire route for a specified time period from only one rail car or train coach. The observer on-board the rail car also counted the number of passengers on board between stops (Stopher, 2000). The overall findings will be presented with the current data multiplied by three because the current commuter train set has three train coaches. The counts were used to determine the passenger load factor or passenger volumes on a *KTM Komuter* line such as maximum load points, variations in loads between *KTM Komuter*, maximum loads, schedule adherence, destination and origin locations, the distribution of passenger trip lengths on the line (passenger km or boarding density), revenues, system ridership patterns, boarding passenger totals (travel density, passenger-km/km) and passenger boarding and alighting times or door close times at train stops and stations or standing times of the trains. These reflect all the information needed for scheduling, operations, line demand and usage quality of stops and stations (Vuchic, 2005). ‘A good representation of public transport demand can usually be achieved if the trip matrix is based on a survey, in which passengers are directly asked about their precise origin and destination’ based on a study conducted by Ceder (2007). As a concluding remark, passenger boarding and alighting surveys provided information and data on Usage of Services. The equipment of passenger boarding and alighting surveys consisted of a special field sheet, clipboard, pen and watch. A simplified example of a summary field data form is given in Appendix C. This field data form was adapted from DOT (1996), KTMB (2004), Vuchic (2005), Adibah (2007) and Ceder (2007). The surveys involved questionnaires given to and completed by rail passengers while they were riding a train (American Public Transportation Association, 2007). During inter-peak and off peak times, the observer or the enumerator had chances to conduct surveys on-board the train instead of on the platforms and waiting areas of the rail stations or stops.

On-board surveys are primarily designed to obtain detailed and better information about each respondent's current trip (Schaller, 2005). The surveys are important for local transportation planning and marketing purposes. Survey results are in the form of where and when customers use public transport services. In short, on-board surveys are very useful in part of O-D surveys in capturing actual travel behaviour information. In other words, on-board surveys estimate public transport-trip O-D matrices. O-D matrices are essential data for most public transport planning and design procedures (Ceder, 2007) and decision making endeavours (American Public Transportation Association, 2007). The main characteristic of on-board surveys is the direct access they provide to commuter rail riders and to targeted specific routes. On-board surveys can be conducted cost-effectively because enumerators can readily reach a large number of rail users or riders. However, much manpower is required for counts. For this reason, such surveys are expensive (Filippi et al., 2013) and time-consuming (American Public Transportation Association and Ceder, 2007). Direct access to customers means that on-board surveys are able to reach the targeted population to gauge involvement levels from prospective respondents. It also means that the on-board surveys have the ability to obtain a representative sample of a certain population and the ability to conduct a survey during the immediate experience of the service (Schaller, 2005). Furthermore, the enumerator must be alert towards the exact seating, space provided for the number of standees and total capacities of trains well so that she or he can accurately estimate the number of passengers in a full train.

Train volume studies were conducted to investigate the number of trains that had been used in the line. These studies were conducted at Port Klang and Sentul stations for two days.

5.4 DATA PROCESSING AND ANALYSIS

Data analysis is a crucial process that translates survey responses into meaningful findings. Steps in data analysis include: editing and coding survey data, inputting them in the computer in a software-readable format, doing basic or descriptive statistics analysis such as frequency distribution and means and cross-tabulation analysis to generate insights and resorting to higher order analyses such as factor analysis and SEM-AMOS. Data analyses for survey research can be conducted using SPSS and Microsoft Excel. Cross-tabulation analysis assesses the strength of relationships between two or more variables. For making inferences from cross-tabulation, it is vital to compute percentages along the causal variable. Then, interpreting the data and making recommendations pertaining to the research objectives are equally pertinent. The primarily selected service quality attributes were identified through a thorough literature review. These service quality attributes are listed in Table 5.9.

Table 5.9 Rail Service Quality Attributes

Factors	Rail Service Quality Attributes
f1	riding quality on the train
f2	station/stop quality
f3	convenience
f4	transfer facilities (stair-climbing, escalator, cross-platform transfers)
f5	service frequency
f6	schedules
f7	reliability or punctuality
f8	safety and security
f9	aesthetics
f10	environmental friendliness
f11	comfort of train coach (interior)
f12	air-conditioning in train coaches
f13	cleanliness of train coaches
f14	seat
f15	litter bins
f16	fully covered platforms
f17	cleanliness of platforms and stations
f18	staff courtesy
f19	customer services
f20	fares
f21	number of retail outlets
f22	parking lots
f23	park-and-ride capacity
f24	kiss-and-ride size
f25	availability of seats
f26	standing space
f27	station lightings

Table 5.9 continued

f28	safety equipment
f29	toilets, showers and prayer rooms
f30	baby-changing facilities
f31	overhead bridge
f32	facilities for handicapped groups
f33	parent(s) including small children facilities
f34	telephones
f35	passenger information: route time clock
f36	passenger information: signages and notice boards
f37	suggestions & complaints management systems
f38	feeder bus services
f39	Auto Teller Machines (ATMs)
f40	turnstile
f41	ticket counters
f42	Ticket Vending Machines (TVMs)
f43	electronic ticketing system: smart card, Touch n Go (TnG), etc.
f44	level of service (LOS)
f45	overall service quality

For example, aesthetics defines the shape of the train and coaches from many views i.e., the frontal view of the train and the interior of train coaches. In short, aesthetics relates to the train's beauty or its attraction capabilities.

Public transport demand model is one of techniques of public transport data analysis. It is developed to analyze public transport users' behaviour for planning purposes. To be more precise, this method of public transport data analysis has gone some way towards enhancing the researcher's understanding of the spatial and temporal details of public transport decisions essential for facility planning and management. Public transport demand models reveal some basic findings about transportation (travellers' and vehicles') behaviour by presenting two kinds of estimates: price and service elasticities of demand; and decision-makers' values of travel time. This is exemplified by Small and Winston (1999) where the parameter estimates, implied values of time and elasticities obtained from public transport demand models are critical inputs into public policies. To put it another way, practical experience suggests that public transport demand models have contributed to accurate and informative evidence to public policy debates and planning.

5.5 DATA REQUIREMENTS

More detailed descriptive information on every variable and the total sample will be obtained. Primary data consists of rail services data. Rail services data are the actual capacity and the type (quality and quantity) of rolling stocks that provide information on overcrowding (an aspect of service quality) (relevant photos from periodical observations and on-site measurements) and emissions. These data need to be collected on a quarterly basis.

5.5.1 List of Data (Hard and Soft) Variables

a) transfer activities (transfer time, quantity, location, distance, and type);

b) route O-D matrices by stops - routes selected on a trip (route choice analysis) i.e., stations of origin and destination;

c) trip origin;

d) trip destination;

e) passenger loads;

f) passenger waiting times;

g) passenger walking distances;

h) passengers boarding and alighting, and TU loads at all points along the line;

i) average running (travel) times;

j) on-time performance (percentage vehicle arriving on time at stops/stations) or service reliability data;

k) station standing or dwell times;

l) door opening and closing times;

m) acceleration, deceleration, maximum cruising speed, maximum speed from the previous stop;

n) sources of information on commuter rail as popular travel mode;

o) access time, costs, mode and distance;

p) egress time, costs, mode and distance;

q) reasons for using commuter rail;

r) time when commuter rails were first utilised;

s) purpose of trip;

t) time of travel;

u) day of week of travel;

v) frequency of use;

w) frequency of travel;

x) type of payment or ticket type;

y) fare paid per trip;

z) personal variables and socio-economic data (gender, age, nationality, race; marital status; family background and size (These will provide guidance on the number of potential riders); occupation, employment status (private or government or industry, etc.); education background; type of physical appearance and special groups; monthly income, private vehicle ownership);

aa) passengers' attitude with respect to service qualities like riding comfort, convenience, safety and security, aesthetics, and cleanliness;

bb) importance of and satisfaction on (z) for passengers' mode choice for travelling;

cc) total trip length by direction (or line if it is the network service design) and station;

dd) total passenger-kilometres;

ee) average distance travelled; and

ff) vehicle hours.

*(aa) – (dd) are hypothetical variables that will achieve the key aim of improving the quality of the national commuter rail services.

Calculation of passenger walking distances from the origin points to the *KTM Komuter* stations and from the *KTM Komuter* stations to the destination points was estimated in the O-D surveys using distance measurement of the Google Earth mapping. Similar to the research of Daniels and Mulley (2013), the distance was an approximation due to a possibility of passengers not using the road network. Instead they might have walked through parks and open spaces or use short cuts, which could reduce their walking distances. Or, they might have walked longer than the shortest road network distance because the longer route is safer and/or that they wanted to walk for leisure and sightseeing.

The rail corridor-specific data needed for improving the quality of rail corridor services and operations (travel patterns of both rail riders and car transit units) based on DOT (1996), Vuchic (2005), Adibah (2007), Ceder (2007) and Jain et al. (2014) are as follows:-

Data on trip characteristics:

a) commuter train (transit unit, TU) loads at all points along the corridor;

b) loads at key points;

c) running time;

d) schedule adherence (focus on departure and arrival times);

e) fares, costs and revenues; and

f) the characteristics of passengers like the most accurate number of total boarding and alighting passengers at each stop or station along the corridor length.

Based on the above data variables, the appropriate data collection methods and survey instruments are summarised in the Table 5.10. Table 5.11 lists out the data and parameters as well as data sources for optimization exercises.

Table 5.10 Data Collection Methods and Survey Instruments based on *KTM Komuter* Passenger and Rail Data Variables

***KTM Komuter* on Port Klang-Sentul Corridor Data Variables**	**Development of Data Collection Methodology and Survey Instruments** (A Series of Direct Interviews)
Personal (Demographic) Profiles	
The characteristics of passengers	O-D and Attitudinal surveys
Ridership and Rail Car Profiles	
The total passenger volumes and commuter rail coach loads	Passenger Boarding and Alighting surveys
Loads at key points	Key point load checks
Travel Behaviour and Time Information Trip characteristics using commuter rail	
Running time	O-D surveys
Schedule adherence (focus on departure and arrival times)	
Fares, Costs and Revenues	
Level of Service and Service Quality Improvements for Increased Rail Market Passengers' attitude, opinion of, preferences, and importance of and satisfaction on…	
Riding comfort	Attitudinal surveys
Convenience	
Safety and Security	
Aesthetics	
Cleanliness	
Support facilities for disabled riders	
Support facilities for parent(s) plus small children	

Sources: DOT (1996); KTMB (2004); Vuchic (2005); Adibah (2007); Ceder (2007); Jain et al. (2014)

Table 5.11 Variables, System and Design Parameters for Optimising Urban Public Transport Single Corridor Design

Data Variables and Parameters	Equation Notation	Unit	Data Source(s)
Average access distance	D_a	km; m	O-D survey
Line spacing; a line width of a unit study area	D_l	km; m	Observational Study and Field Measurements
The optimal line spacing on a rail line	D_l^*	km; m	Optimisation Method
Stop spacing	D_s	km; m	*KTM Komuter* Service Department of the *KTMB*
The optimal stop spacing on a rail line	D_s^*	km; m	Optimisation Method
Average travel distance; Average trip length to the city centre	D_c	km; m	Passenger Boarding and Alighting Surveys (On-board Passenger Surveys)
Weighted sum of the average trip length to the city centre for each sub-population	$\overline{D}_c$	km; m	On-board Passenger Surveys
A line length of a unit study area	D_u	km; m	Observational Study and Field Measurements
Access speed	v_a	km/h	Operations Department of *KTMB* and the driver(s) of the commuter train
Cycle speed	v_c	km/h	
Cycle time	T	minutes	
Headway	h	minutes	
Optimal headway	h^*	minutes	Optimisation Method
Fleet size or the total number of vehicles needed for operation of a line, or of an entire network	N	Transit Unit (TU)*	*KTM Komuter* Service Department of *KTMB*
Number of radial lines in a radial city centre	N_r	-	National Public Transport Demand Model

Table 5.11 continued

Number of TUs	N_{TU}	TU	*KTM Komuter* Service Department of *KTMB*
Factor accessing distance; routing factor for the actual access distance as a function of D_s and D_l	f_a	-	National Public Transport Demand Model
Factor for accessing distance perpendicular to the radial line: π/3	f_c	-	National Public Transport Demand Model
Maximum speed of public transport	v	km/h	Operations Department of *KTMB* and the driver(s) of the commuter train
Time lost at stops	T_s	seconds	Passenger Boarding Surveys
Factor involving waiting time	f_w	-	National Public Transport Demand Model or Transport Analysis Guidance of the UK Department for Transport
Average access time	T_a	minutes	O-D Survey
Total weighted travel time to the city centre	T_c		Field Measurements and O-D Survey
Average waiting time	T_w		O-D Survey
Average in-vehicle time	T_i		O-D Survey
In-vehicle time within the unit study area	T_u		Observational Study and Field Measurements
Average walking (transfer) time	T_t		O-D Survey
Average egress time	T_e		O-D Survey

Table 5.11 continued

Constant for the weighted egress time of city centre oriented trips and transfer penalties for transversal trips	$\overline{T}_{et}$		Transport Analysis Guidance of the UK Department for Transport and Passenger Demand Forecasting Handbook 2002
Regular frequency	F	veh/h	*KTM Komuter* Service Department of *KTMB*
The total cost for passengers alighting the line	C_a	\$/h	Passenger Alighting Surveys
The total cost for passengers boarding the line	C_b	\$/h	Passenger Boarding Surveys
Total operator cost per hour	C_o	\$/h	Corporate Planning Service Department of *KTMB*
Total user or passenger cost per hour	C_P	\$/h	
Total external cost per hour	C_e	\$/h	
The total cost for passengers going through	C_t	\$/h	On-board Passenger Surveys
Weight for access time	w_a	-	Transport Analysis Guidance of the UK Department for Transport
Weight for waiting time	w_w		
Weight for in-vehicle time	w_i		
Weight for walking (transfer) time	w_t		
Weight for egress time	w_e		
Weight for time element *x*	w_x		
Average value of passenger time	c_p		OD Surveys
Hourly cost of TU operation, that is driver and vehicle costs	c_o	\$/(TU-h)	Corporate Planning Service Department of *KTMB*
Hourly cost of TU operation	c_e	\$/(TU km-h), \$/(passengers km-h)	

Table 5.11 continued

Vehicle and Passenger Occupancies based on distance travelled	E_r	TU km, passengers km	Observational Study and Field Measurements
Number of passengers per hour travelling on the line	P_L	passengers/h	On-board Passenger Surveys
Number of passengers boarding along the entire line	P_B	passengers/h	Passenger Boarding Counts
Passengers alighting in the unit area	P_a	passengers per unit area	Passenger Alighting Counts
Passengers boarding in the unit area	P_b	passengers per unit area	Passenger Boarding Counts
Design passenger volume	P_d	passengers/h	On-board Passenger Surveys
Number of trips for trip type *j*	P_j	-	On-board Passenger Surveys
Maximum number of passengers boarding along the entire line	$P_{\max}$	passengers/h	Passenger Boarding Counts
The number of passengers going through the unit area	P_t	passengers per unit area	On-board Passenger Surveys
Travel demand per square kilometre unit area (FIXED)	P	/km^2	Observational Study and Field Measurements
Peak hour coefficient [the inverse of the peak hour factor (PHF)]	PHC	-	*KTM Komuter* Service Department of *KTMB*
The TU (bus or train) capacity	C_{TU}	spaces/TU	
The optimal value of the vehicle capacity	C^*_{TU}	spaces/TU	Optimisation Method

Table 5.11 continued

Static vehicle capacity (seats only or seats plus standing spaces or ratio of seats to standing spaces)	C_{υ}	spaces/veh	*KTM Komuter* Service Department of *KTMB;* Observational Study and Field Measurements
Load factor-capacity utilization coefficient	α	passengers/space	On-board Passenger Surveys
Maximum load factor-capacity utilization coefficient	$\alpha_{\max}$	passengers/space	Key point load checks via On-board Passenger Surveys and *KTM Komuter* Service Department of *KTMB*
Terminal time coefficient	γ	%	Observational Study and Field Measurements
Length of rail line	L	km	*KTM Komuter* Service Department of *KTMB*
Number of vehicles per TU	n	veh/TU	
Ratio of passenger volume on maximum load section (MLS) to the volume on the entire line	η_p	-	Point Load Checks via On-board Passenger Surveys

*Transit Unit (TU) refers to at least one public transport vehicle (bus or train) travelling together as a physical unit. Joint term for single vehicle and train of several vehicles (a set of *n* vehicles travelling physically coupled together; for train operation, (n > 1) (*n* is also known as train consist in rail transit terminology).

*Weight for time elements for conversion into monetary values will be estimated based on Wardman's (2004) and the Transport Analysis Guidance (TAG) of the Department for Transport (DfT, 2012).

MLS = Maximum load section is a station spacing with maximum passenger volume that determines required line capacity.

Sources: van Nes (2000, 2002), Vuchic (2005, 2007), Ceder (2003, 2007), and DfT (2009)

5.6 DATA AVAILABILITY

The respondents for the surveys were also obtained from the Seremban – Rawang line especially at four minor and major interchange (transfer) stations namely Putra, Bank Negara, Kuala Lumpur and KL Sentral since these stations were also regarded as survey locations.

Secondary data sources were required from *KTMB* (the Malaysia Railway Berhad or the *KTM Komuter* train operator). Such secondary data were designed route characteristics and mode characteristics for Port Klang-KL Sentral-Sentul line to complement the actual services data as stated under Section 5.5. Other secondary data sources were annual ridership per station from 1995 to 2014, annual revenue per station from 2008 to 2012, maximum load factor per station (capacity per train) from 2008 to 2012 and cost data. Cost data included the profit and loss statements, driver and vehicle costs per hour, passenger waiting time cost per hour, total user or passenger cost per hour, total operator cost per hour, total negative externalities costs and farebox ratios. All of these cost data were provided from 2008 to 2012.

5.7 DATA GAPS

The present research has a number of gaps or limitations. There is no need for a pilot test or pre-test to be conducted prior to the actual field surveys to collect data until a process becomes data saturated because of time, manpower and budget constraints.

There is no specific and accurate information on elasticities and future GJT to calculate the estimated GJT Elasticities based on the PDFH (The Association of Train Operating Companies, 2002).

There is no exact information about *KTM Komuter* passenger trips per hour except for the estimated ones i.e. the maximum passenger trips per hour from the annual ridership per station provided by *KTMB* which were calculated using a Microsoft Excel software.

There is no specific Malaysian data on service interval and interchange penalties in order to calculate the GJT. Similarly, there are no Malaysian values of time in order to compute the GTC and optimal price(s). Consequently, British currency value apart from Malaysian currency value is used to compute the values of time in order that both the GTC and optimal price(s) can be calculated. Not only was there absence of Malaysian data but also, there was no Malaysian Technical Manuals to serve as a guide for technical decision-making. As a result, the British's Technical Manuals, for example, the Passenger Demand Forecasting Handbook, PDFH 2002 and Transport Analysis Guidance, TAG of the UK Department for Transport were used to calculate both the GJT and GTC.

Based on de Oña et al. (2012), more variables of public transport service quality attributes like train temperature, train speed, accessibility to/from the train and rail stations proximity to/from origin/destination are proposed as direct questions of the Attitudinal surveys or alike the Passenger/Customer Satisfaction Surveys in future to improve the methodology of surveys.

Satisfaction (passenger) gap is lack of knowledge and experience on passenger expectations or desired quality of service. In the case of *KTM Komuter* passengers, they misjudged the LOS and overall service quality of the *KTM Komuter* due to lack of knowledge and experience using *KTM Komuter* as a primary mode of transport. Their answers were probably influenced by the interviewer too (Too and Earl, 2010).

Other data gaps are passengers' opinion of service and facility changes, including support facilities for disabled riders and support facilities for parent(s) including small children; and passengers' attitude toward fare changes or different fare categories (i.e., students, school children, teenagers, adults, family, large groups, the disabled and elderly groups, wheel chairbound users, parent(s) with small children, parent(s) with strollers/prams, and special fare; free-, transfer-, and monthly-passes; working and non-working trips). These data and information could be gathered accurately through the Stated Preference (SP) surveys rather than the Stated and Derived Importance methods (de Oña et al., 2012). These SP surveys are used to model the actual or true choice behaviour of individuals with respect to hypothetical situations (Chowdhury et al., 2014) because they have strong theoretical foundation based on economic theory and they aid estimation of the importance of each public transport service quality attribute from passengers' responses as choice sets (Kumar et al., 2004). However, Chowdhury et al. (2014) questioned the reliability of the results of SP surveys due to hypothetical situations because the responses probably do not fully match up the actual choice behaviour.

There was no separate weekend data on passenger counts to produce weekend public timetable printouts.

5.8 CONCLUSIONS

The accuracy of the estimates is governed by the sampling design, characteristics of data, size of sample and selection of sample. Convenience samples mean conveniently or economically selected elements for the ease and speed of sampling. Convenience samples are used because the researcher aims to obtain a large number of completed questionnaires quickly and economically. If an appropriate sampling design is used, a large size of sample will in itself allow the findings to be generalized. The questionnaires will determine the type of statistical analysis and modelling technique(s) that will be used. Data availability and list of data requirements will determine the appropriate methods of data collection. There are data gaps that cause computations, results and estimations to be unacceptably inaccurate.

Hence, the data collection methods employed ensured that all personal and situational information were recorded since they were compounded by observational studies (this is to accurately measure the users' behaviour. Filippi et al. (2013) provided a means of surveying actual mobility demand) questionnaire surveys and surveys gauging user environment (Willis et al., 2000). Personal and situational information characterise the decisions and actions taken by the passengers thus aiding in the design of *KTM Komuter* service.

CHAPTER 6 : RESULT: O-D SURVEYS

A sample questionnaire form for Origin Destination (O-D) surveys is attached in Appendix B. A detailed descriptive statistical analysis and explanation of each explanatory variable is done and the survey results are also shown in this chapter. These basic descriptive statistics were utilized to summarize both the travels or trips made and the passengers' personal (socio-economic) characteristics. These O-D surveys envisage the terminal- and O-D-oriented concepts of measurement of LOS in transport in accordance to Macário's (2010) research.

6.1 INTRODUCTION

O-D surveys provide valuable information and understanding on travel behaviour of both the users and the *KTM Komuter*, particularly for a single trip. It is also regarded as an empirical evaluation of the existing *KTM Komuter* service and trip by travel time or *KTM Komuter* schedule (Siti Nurbaya et al., 2013). This is because the development of timetable requires the LOS to satisfy passenger flows between O-D stations within the hours of *KTM Komuter* service (Albrecht and Howlett, 2009). Rationally, this is very important because it will relatively reduce the average round trip travel time of the train when both the large headways between trains and the poor waiting times of the users are reduced too. These surveys involved direct interviews and paper-based survey methods and were done at both the railway station platforms and on board trains. The O-D surveys were done from 6.30 AM to 9.00 PM, targeting three peak hours particularly the evening rush (1630

– 2030) because *KTMB* periodical studies have proven that this is the worst period with so many technical faults experienced by the trains and that there is great overcrowding at platforms and coaches (Siti Nurbaya et al., 2013). Data on return transport modes was roughly an estimate. Detailed trips to return home and for driving someone else were excluded from the analysis.

Haphazard and uncontrolled land use for development deliberately planned for private cars has brought about urban to suburban areas being poorly furnished with the national commuter rail service (Siti Nurbaya et al., 2013). This describes the continuing phenomenon of the KL urban sprawl (Denke, 2003, Kenworthy, 2009, Cao et al., 2007, Homem de Almeida Correia et al., 2013). Hence, proper planning and designing for an integrated regional rail route for KL city and Klang Valley would require in-depth investigations on the nature of the present *KTM Komuter* travel demand and *KTM Komuter* service (Huisman et al., 2005; Gallo et al., 2011). This chapter presents and reviews the results of the O-D surveys. The results provide (Siti Nurbaya et al., 2013):

a) the travel behavioural patterns and information of *KTM Komuter* users, which also means they also highlight *KTM Komuter's* demand and service patterns; For instance, the multimodal travel analysis should be conducted as part of the O-D surveys to capture the related travel behaviour of passengers. By analyzing passengers who take the *KTM Komuter* with one or more other modes as part of their linked trips, the interactions among modes can be better understood;

and

b) an understanding on the characteristics of the commuter trains primarily plying the Pelabuhan Kelang – Sentul line.

6.2 SURVEY LOCATIONS

In the beginning, six railway stations were selected for the O-D surveys. They were Kuala Lumpur Sentral (KLS), Kuala Lumpur (KL), Bank Negara, Putra, Shah Alam and Subang Jaya. They were selected for survey locations because they had high ridership based on previous *KTMB* studies and a review of several surveys found in the research in Universiti Teknologi MARA. KLS and KL stations are major transfer (interchange) stations whereas Bank Negara and Putra are minor ones. Figures 6.1 and 6.2 show the *KTM Komuter* route map and its integration with other KL rail services. While conducting the surveys at sites, one aspect that could not be avoided was that the interviews could not be completed at the platforms. To address this problem, the surveyors had to follow their respondents to be on board the train. They also had to alight the train immediately whenever they had completed the questionnaires or alight the train where these respondents alighted at the final railway stations if they could not complete the interviewing session. When this happened, the surveyors had to avoid time wastage by locating for respondents at a particular station. For this reason, there were fourteen survey locations, including Jalan Kastam, Pantai Dalam, Serdang, Kelang, Kampung Dato' Harun, Padang Jawa, Sentul and Pelabuhan Kelang (Siti Nurbaya et al., 2013).

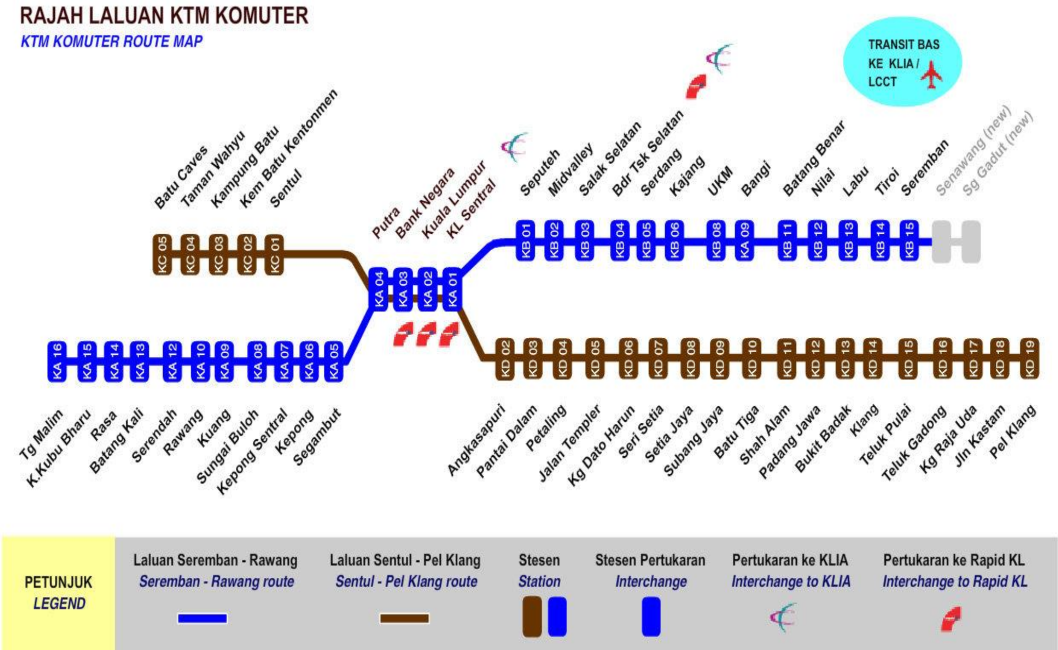


Figure 6.1 *KTM Komuter* Route Map

Sections 6.3 and 6.4 described sample characteristics' of *KTM Komuter* trip-making activities and of *KTM Komuter* passengers respectively.

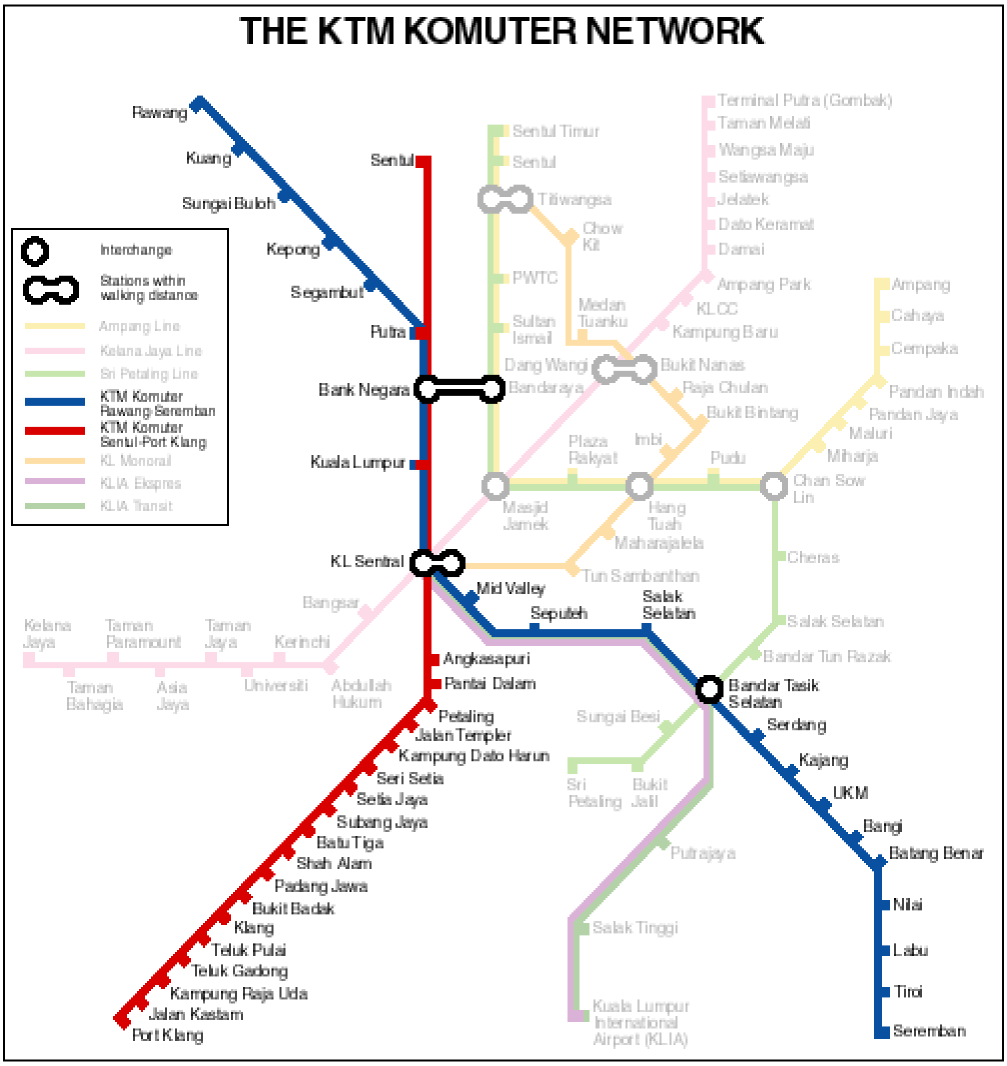


Figure 6.2 *KTM Komuter* Route Integration with Other Rail Services

6.3 TRAVEL BEHAVIOURAL PATTERNS AND INFORMATION OF COMMUTING *KTM KOMUTER*

O-D survey results provided valuable travel behavioural information such as the distributions of place of origin, boarding and alighting railway stations, destination locations, aspects that were typically associated with accessibility of the rail station (Curl et al., 2011) such as the access mode of transport, travel time, distance and cost; and the egress mode of transport, travel time, distance and cost; transfer points and transfer time for a one-way trip (Siti Nurbaya et al., 2013). Such results do contribute to the detailed investigation of the travel behaviour effects with respect to the feasible parameters estimation of volume of both *KTM Komuter* users and *KTM Komuter* trains since the key research objective is to model the travel behaviour of *KTM Komuter* users (Larrain and Muñoz, 2008, Amri, 2008, Mohd Khalis Ikhwan, 2007, Harmize, 2008, Huisman et al., 2005). This is similar to the research objective of Moniruzzaman and Páez (2012) which was to investigate the implications of accessibility to train and accessibility by train for mode shares. This travel behaviour is further described by the capacity, built environment and LOS of *KTM Komuter* (Hine, 2002; Moniruzzaman and Páez, 2012). Passenger flows are at random and uniformly distributed with the assumption that passengers have no information about the schedule although the on-board signages should be ready to provide them with the required information (Nökel and Wekeck, 2009).

The railway station with the highest proportion of boarding passengers where the survey was conducted was KLS with 113 person trips (30.0%). This is most likely because of its vital role as an integrated public transportation hub in KL. Other stations with a substantial number of passenger demand were Subang Jaya with 91 (24.1%) person trips. Person trips from Shah Alam were 71 (18.8%) and KL 58 (15.4%). Bank Negara had 27 (7.2%) starting trips. All these stations are established stations.

The railway station of origin with the highest proportion of boarding passengers was Subang Jaya with 88 person trips (23.3%). Other stations with a substantial number of passenger demand involved KLS with 74 (19.6%) person trips, Shah Alam 71 (18.8%) person trips, KL 45 (11.9%) person trips and Bank Negara, 29 (7.7%) starting trips.

The national travel demand study had conducted observations on the total cross-cordon private transport and public transport to obtain the distribution of mode choice in 2002. Geographically, O-D zones can be divided into two major areas, namely O-D zones within KL Central Planning Area (CPA), which is spatially estimated by the Middle Ring Road 1 (MRR1) cordoned off with a radius of 2.5 km in length and the O-D zones out of KL Metropolitan or within the suburban areas in the Klang Valley, which is spatially estimated at the outer Middle Ring Road 2 (MRR2) cordoned of by a ring with a radius of at least 10.0 km in length. KL CPA represents the KL city centre with KLS serving as a strategic focal point (multimodal transport hub transfer) for transferring of bus, taxi and rail services between stations. O-D zones are used to group the responses to questions 1 and 4.

KL was the most frequently recorded origin place with 106 person trips (28.1%). Other most frequently reported origin places were Shah Alam (77 or 20.4%) and Subang Jaya (73 or 19.4%).

Destination railway stations with high passenger demand was also KLS depicting the same result of origin railway stations with 74 (19.6%) person trips, Subang Jaya (26 or 6.9%), Shah Alam (25 or 6.6%), Bank Negara (24 or 6.4%), Mid Valley (22 or 5.8%) and Klang (20 or 5.3%).

KL appeared to be the most frequently reported destination place with 47 trips (12.5%). Other frequent destinations were Shah Alam (33 or 8.8%), Klang (25 or 6.6%), Subang Jaya, KLS and Mid Valley (22 or 5.8%), Petaling Jaya (19, 5.0%) and Sogo, TAR and the Masjid Jamek shopping areas (15 or 4.0%).

In terms of the entire route choice of the users, observations recorded that 57.6% trips covered city destinations [or *KTM Komuter* routes (corridors) into the centralized business district, CBD] whereas 13.0% of these trips involved transferring to final railway stations to continue a single trip. The passenger flows were identified primarily on directions such as Pelabuhan Kelang (34.2%) to the western regions of Peninsular Malaysia and as far as Pulau Indah, Klang where the location of West Port is, and Tanjung Balai and Dumai, Riau in Sumatera, Indonesia; Sentul (33.7%), which is the area dispersion of passengers towards city centre and to the northern part of the outer KL city centre, heading south i.e., Seremban (11.1%).

Data for the Question ‘Is this your house?’ can be associated with home-based and non-home-based trips. 219 (58.1%) responses were from those not originating from home. Figure 6.3 shows the primary trip purposes. The following were reliable travel behaviour data for a variety of primary trip purposes. Work commute was the largest reported purpose with 175 trips (46.5%). The next largest recorded purposes were home-based trips with 71 (18.8%) and social trips at 58 (15.5%). Social trips like visiting friends/relatives consisted of 53 (14.1%) trips. Complex trips which were characterized by multipurposes amounted to only 1.5% of the overall sampled trips. It can be said that 246 (65.3%) of the users made work and home trips regularly. Questionnaire distributions were done mainly during peak hours to obtain as high as 230 (61.0%) users and during inter-peak hours with 119 (31.6%) users for weekday trips. Moreover, data became reliable and valid with more than 80.0% being observed during weekdays. 317 (84.0%) of the respondents travelled between Monday and Friday. The above findings clearly indicated that passengers prioritized activities in deciding travel-making in the real situations (Sakano and Benjamin, 2011). To sum up, the above results were also consistent with that of Lesley's (2009) that different trip purposes depended very much on passengers' income and the economic importance of their trips. This can be described by a value of time (VoT), allowing the time elements of a trip to be converted into monetary cost for using the service also named GTCs where these costs can be expressed in units of money or time (equivalent minutes). As the quality of the journey worsens, the corresponding GTC increases. GTCs also allow patronage and revenue forecasting for demand changes to existing rail services and the projection years for a particular rail line. This perceived VoT to be close to the wage rate of the passenger and an average of 25% can be used for other (non-work) journeys for convenience.

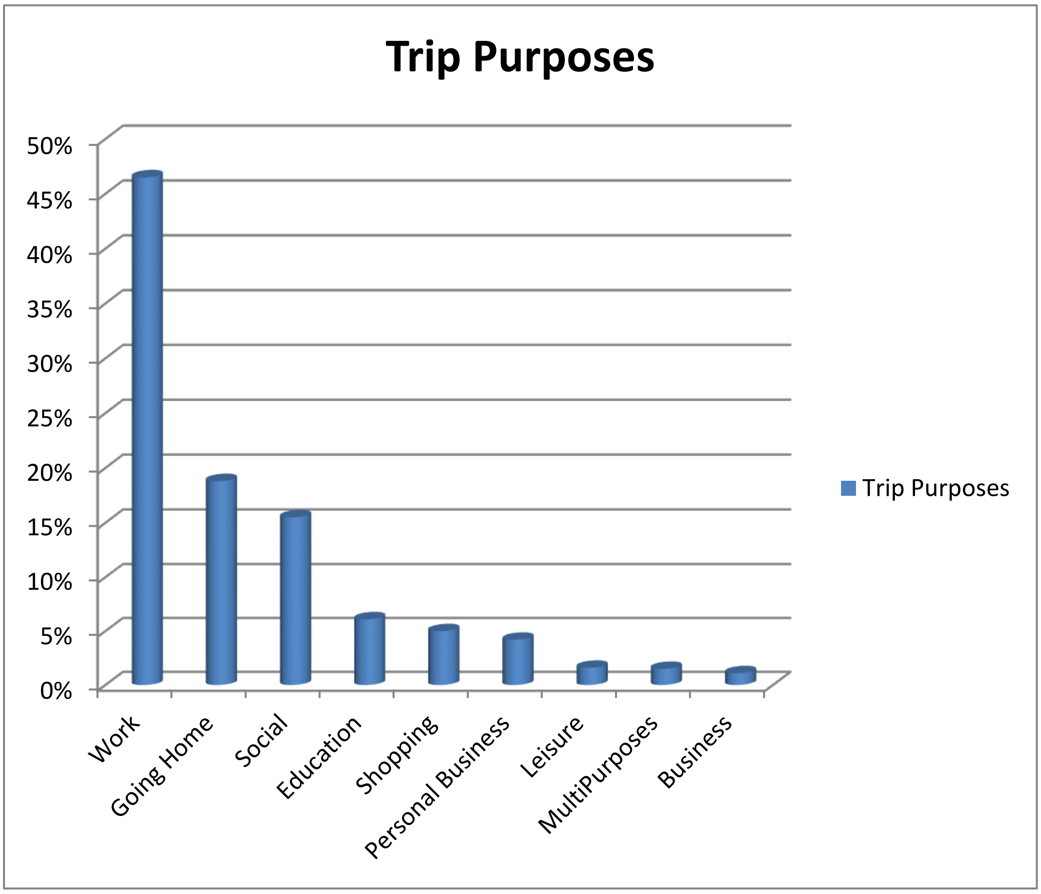


Figure 6.3 Variety of Trip Purposes

Figure 6.4 summarizes the results of travel frequency. The largest proportion of respondents reported that they took the *KTM Komuter* for more than five days a week (144 trips or 38.2%), followed by 89 (23.6%) for one to three times a month and 66 (17.5%) responded that they travelled between two and four days a week. So, 246 (65.3%) of the users were regular or daily users considering they had made six different categories of trips from at least five days a week to once a week. The remaining users used the *KTM Komuter* service irregularly. Some 34.9% used *KTM Komuter* approximately once to three times in a month and at least made trips for the first time, indicating not as commuters and representing a relatively low usage rate.

Preliminary analysis of O-D survey data also resulted in the minimum and maximum number of passengers who began to use *KTM Komuter* in 1995 and 2010 respectively. The 'mean' passengers began to use *KTM Komuter* in 2003.

293 (77.6%) obtained frequent information about *KTM Komuter* service from friends/relatives (50.9%), advertisement at rail stations and other places (16.4%) and websites of the internet (10.3%). Figure 6.5 summarizes modes of transport in the category of unimodal transport. In accordance with Asian Development Bank (2009), there is more than 40.0% mode share for public transport and non-motorized transport in KL compared to many other Asian cities that record 70.0% (Chatterton, 2010). This is due to overdependence of cars and low usage of public transport that were prompted by inadequate and unplanned public transport infrastructure, and poor public transport integration (Asian Development Bank, 2009) and coordination. The increasing reliance on private cars is because of Malaysia is an oil producing country, who have a nationalised oil company like Petronas and therefore oil may well be relatively cheap. Such unplanned public transport infrastructure will be like

route duplication, lack of service coverage and network, unreliable service frequency, and overcrowding during peak hours. For example, Singapore and Hong Kong made 64% and 74% public transport trips, respectively in accordance with Chuen et al. (2014). This sounds desirable to society as such shares promote rationalization of motorized public transport towards urban public transport sustainability (Denke, 2003, Acharya, 2005, Amri, 2008).

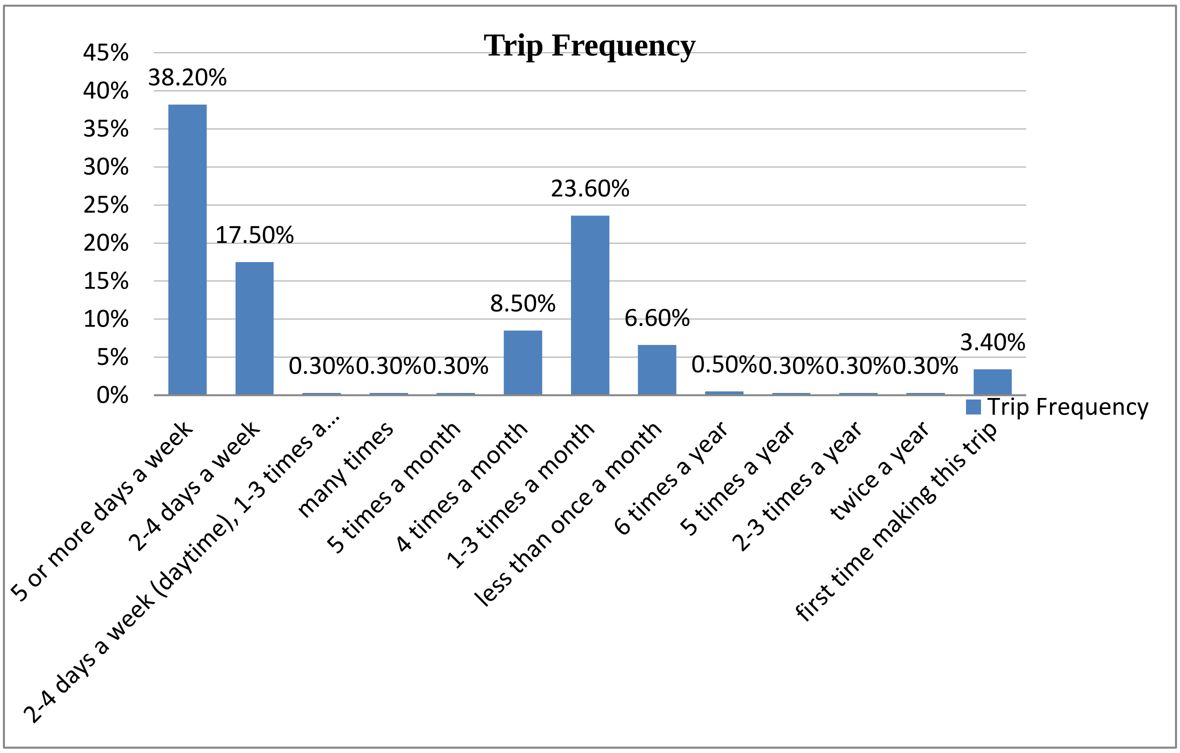
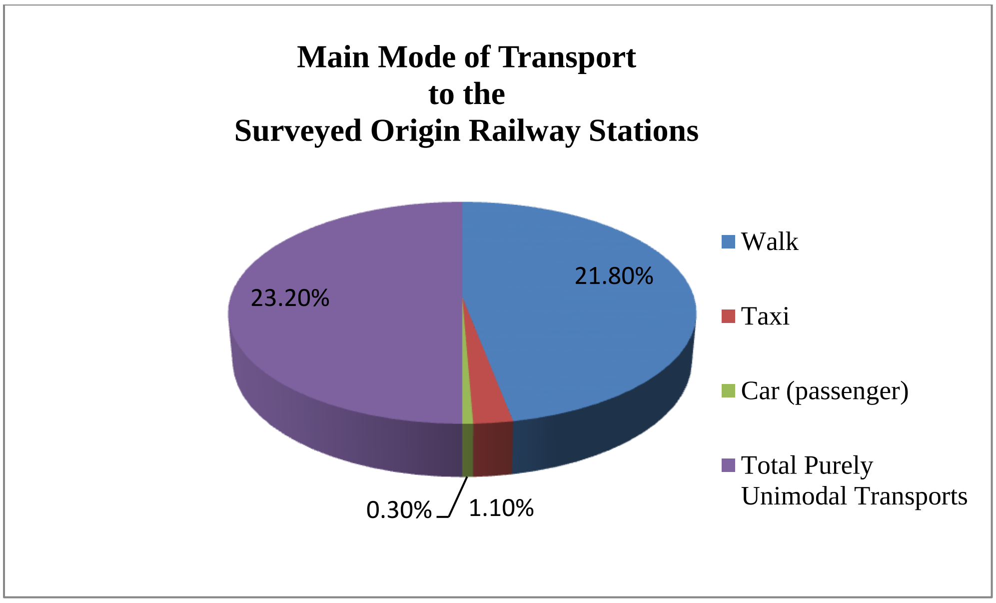


Figure 6.4 Trip Frequency



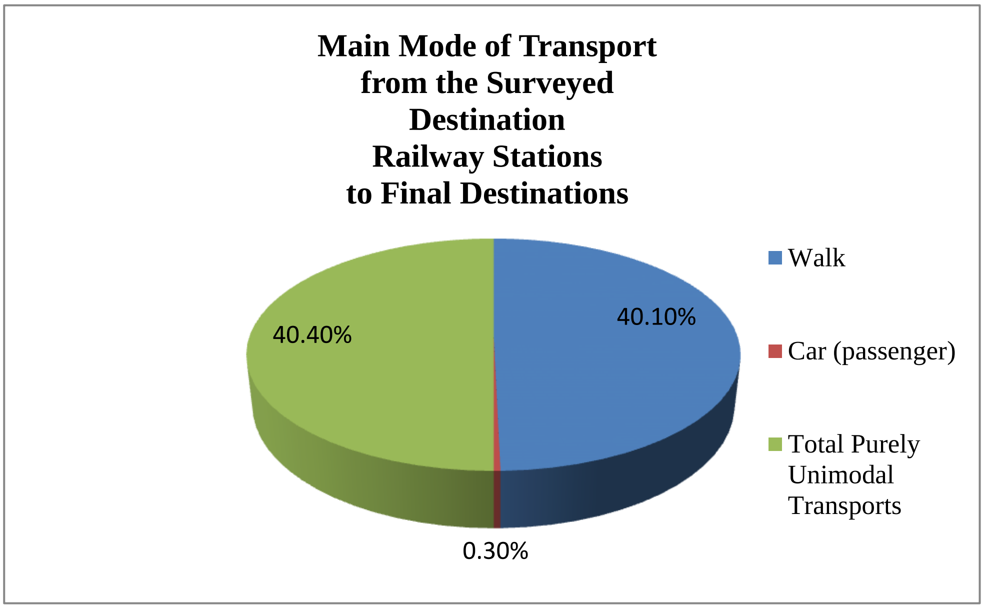


Figure 6.5 Unimodal Transport to the Origin Railway Stations and from the Final Railway Stations to Final Destinations

A review of the means of mobility and modal choice to railway stations of origin and from destination railway stations to final destinations for a single person trip resulted in a high usage of multimodal transport that is approximately 77.0% and 60.0%, respectively (Siti Nurbaya et al., 2013). Multimodal transport comprises at least two vehicular modes of transport, representing a common form of urban travel in association with sustainable transport (Amiruddin et al., 2012). According to Curl et al. (2011), the common barriers in multimodal trips to access destinations ranged from cost, transfer and reliability of services. Therefore, these percentages of multimodal transport (Figure 6.6) suggest a very significant number of person trips. This is an indication of a very significant mixed access and egress travel modes which have caused a poor integration of public transport system in KL and the Klang Valley. In other words, this involved too many transfers and stages in order for passengers to get to their final destinations. Transfer between modes in this context embraced the transfer from the last mode of transport to the first railway station, the event of changing platforms to get to different main routes, the event of alighting from the commuter train to board the LRT systems or the ferry at the related stations and jetty, and finally the transfer from the commuter train as a mainline journey to the connecting mode on the road.

The afore-mentioned statements suggest that transfer is a very important design component in integrated multimodal public transport network (Chowdhury et al., 2014) planning, design and operation (Yew, 2008) and should be made comfortable and convenient so as to boost public transport demand (Jamilah, 1997, Shamsul, 2008) and revenue, and to prioritize the needs for the general public (The Economic Planning Unit, 2010). Hine and Scott (2000), Wardman et al. (2001), Muhammad Faishal (2003), Preston (2012a) and Chowdhury et al. (2014) stressed that transfer facilities should continuously be improved to enable seamless travel as part of a user-friendly integrated public transport system network. Nazery (1997) also supported that the improvement in multimodal linkages and integration will encourage economic growth for efficient transportation of goods in the country. In choosing the route for public transport trips, users would consider a simple, short, direct journey, high-frequency services with minimum weighted travel time (Larrain and Muñoz, 2008, Albrecht and Howlett, 2009) and waiting time (Sparing and Goverde, 2013), that is, its time costs varies with the levels of comfort and convenience or ease (Wardman et al., 2001) and also taking into account that the alternative routes have the same travel costs, and that users normally dislike and frustrated experiencing/making multiple transfers (Larsen and Sunde, 2008, Yew, 2008, Mackett et al., 2006). Users even want to avoid transfers throughout their public transport trips according to Hine and Scott (2000) and Wardman et al. (2001). Hine (2002), Muhammad Faishal (2003) and Chowdhury et al. (2014) stated that the improvement in multimodal transport network integration could reduce wasteful duplication of services that have led to improved transport and land resources. They further said that the improved public transport integration in general can ease people's mobility and accessibility together with low costs of transfers and operation, a cashless public transport system if effective fare integration is practised. Meanwhile, Hine and Grieco (2003) pointed out that people's activities each hour everyday had significant impacts on mobility and accessibility.

The local public transport integration strategy in 2003 proposed that a minimum of two transfers for each trip with transfer time (or lost time in transfer) should not exceed 3.5 minutes and the walking for transferring efficiently between two connections should be restricted to less than one minute for a 60-metre distance. Moreover, on-site measurements resulted in poor transfer time at both origin and destination railway stations with 35 minutes and 25 minutes, respectively (Siti Nurbaya et al., 2013). The corresponding values of observed patrons to stations of origin and to final destinations were 177 (46.9%) and 267 (70.8%). These data highlight the poor functions of the existing transfer points or lack of smoothness in transfer (Ceder, 2007) and that there is an urgent need to improve both the transfer facilities and the provision of transfer station with proper inter-connectivity (Román and Martín, 2011) or convenience of use of the *KTM Komuter* (Vuchic, 2007, Syahriah et al., 2013).

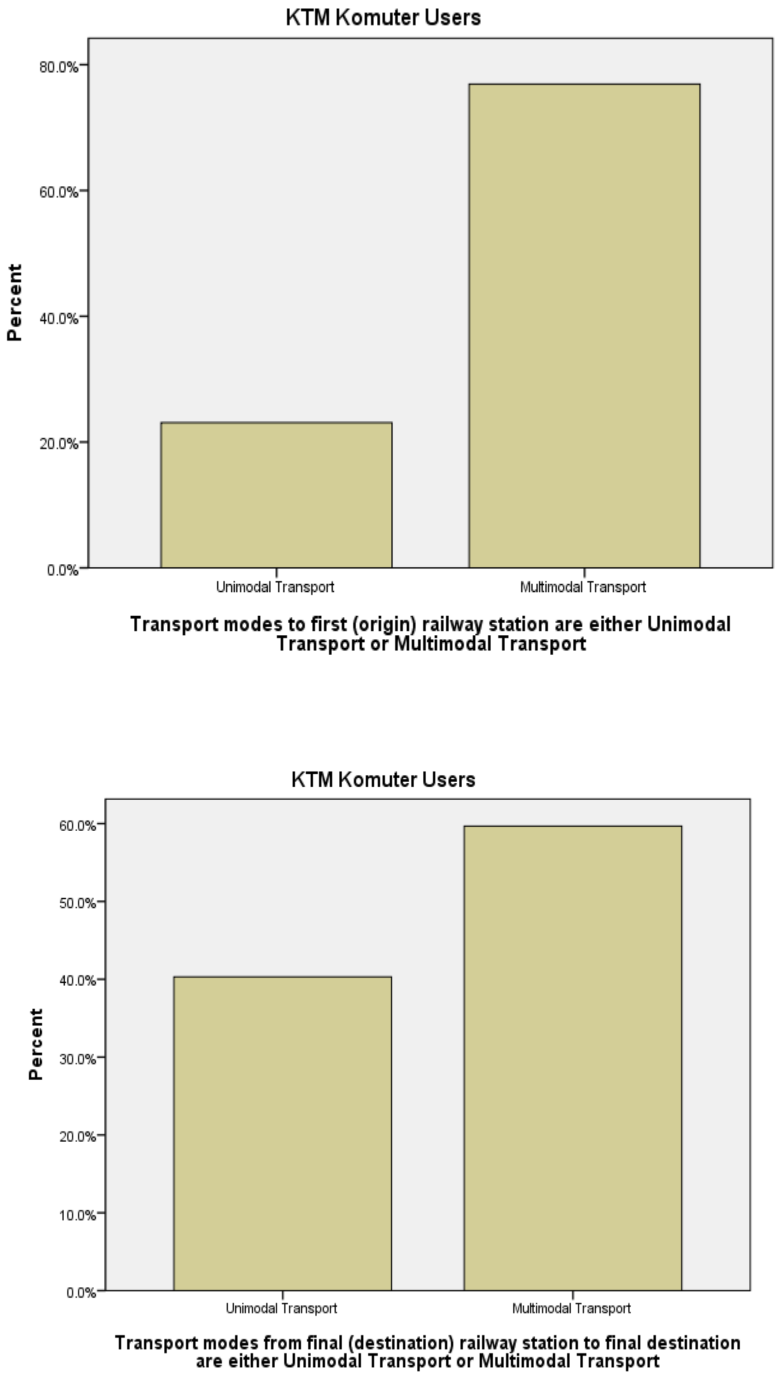


Figure 6.6 Multimodal Transport to and from Railway Stations

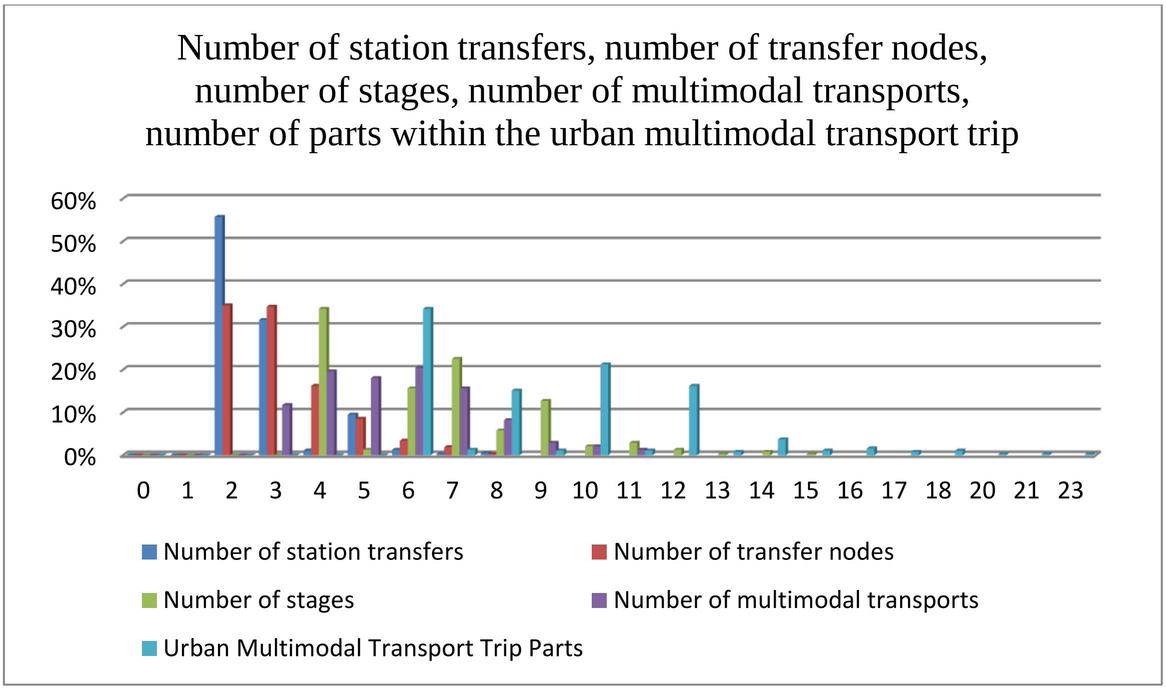


Figure 6.7 Number of Station Transfers, Transfer Nodes, Stages, Multimodal Transports and Number of Parts within the Urban Multimodal Transport Trip for a One-Way Person Trip

From Figure 6.7, (number of transfer nodes = T) can be described in the home to work journey below.

HOME→Walk→T→(Pickup)Bus→T→(Linehaul)Coach→T→(Delivery)Bus→T→Walk→WORK

An example of journey time stages can be described as walk from origin, wait for vehicle, ride in vehicle and walk to destination (Lesley, 2009). Urban multimodal trip parts can be described as HOME→walk(wait, ride) feeder bus→T(wait, ride) *KTM Komuter*→T(wait, ride) bus→walk→WORK for a home to work journey. This example has ten parts that comprises two station transfers and eight stages. T for this example refers to station transfer.

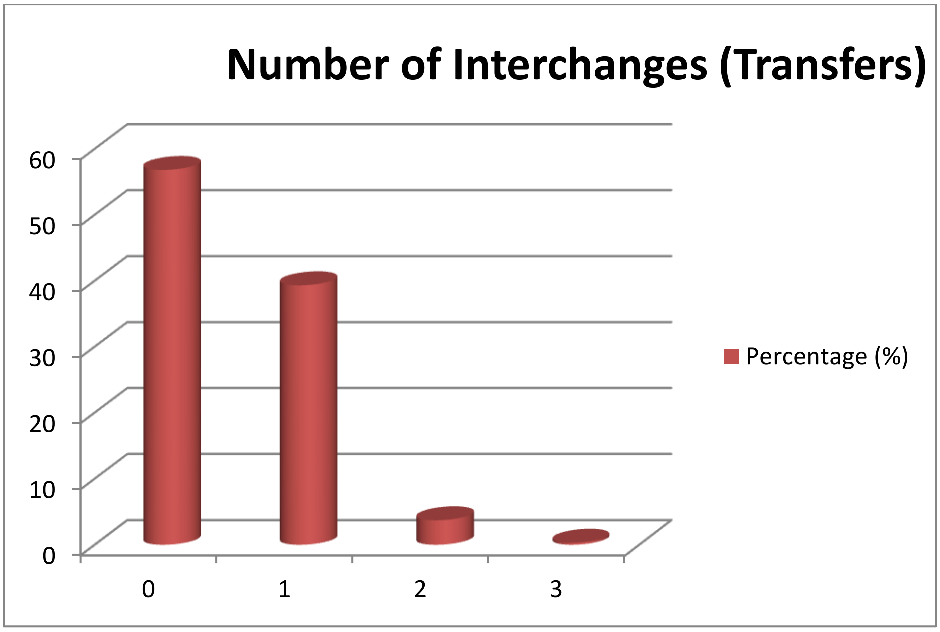
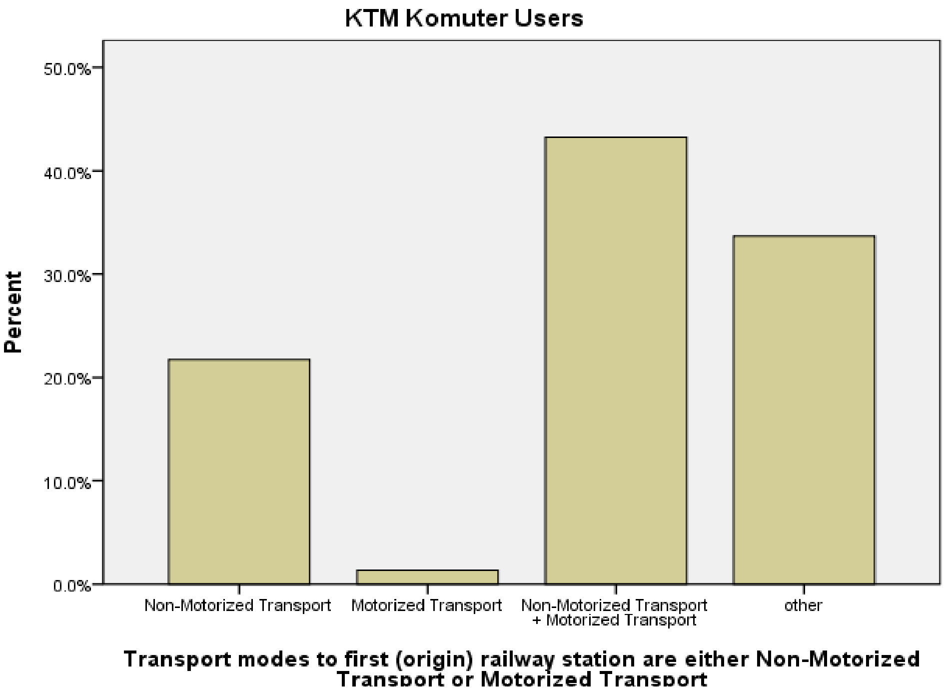


Figure 6.8 Number of Transfers for the entire number of cases
or 377 respondents

Data on return transport modes are also similar in which about 52.0% involved multimodal transport even though 145 (38.5%) of the users had not responded to the related question. The quantity of multimodal transport above in Figure 6.6 can be further defined by looking into the combination of NMT and motorized transport, and other forms of transport in Figure 6.9. NMT to the origin railway station discloses that more than 20.0% of the residents nearby used to walk whereas as guided by Macário (2010) and his team, the 'soft modes' of NMT for the trips from the final railway stations is associated largely with walking and using a bicycle in which the relative proportion is coincidentally reported double. Motorized transport (MT) refers to all private and public transport on roads such as car, taxi, bus and motorcycle. The term Other describes two or more than two transports with the combination of NMT-rail-based transport(s), NMT-road-rail-based transport(s), and NMT-road transport-ferry. Results of Descriptive Statistics Analysis as shown in Figure 6.9 are the Access Transport Modes to Railway Stations where the surveys were conducted are either NMT (22.3%), MT (1.3%), NMT – MT (44.3%) or Other (32.1%) whereas the Egress Transport Modes from Final Railway Stations to Final Destinations are either NMT (40.3%), MT (0.3%), NMT – MT (46.2%) or Other (13.3%).

Figures 6.10 and 6.11 report the main transport modes to the surveyed stations of origin and modes transferred to upon reaching the surveyed final railway stations at destinations. Figure 6.10 highlights that 4.0% of the users who came to the surveyed first railway stations used *KTM Komuter* because they found parking facilities at the railway stations nearby. They claimed that the parking spaces at the railway stations like Jalan Kastam, Kampung Raja Uda, Teluk Gadong, Padang Jawa, Batu Tiga, Pantai Dalam, Petaling, Sentul, Bangi and UKM were free-of-charge. In addition to that, the information on the park-and-ride facilities that were provided by *KTMB* (Car Park) *Sdn. Bhd.* comprised only 18 railways stations that imposed parking charges.



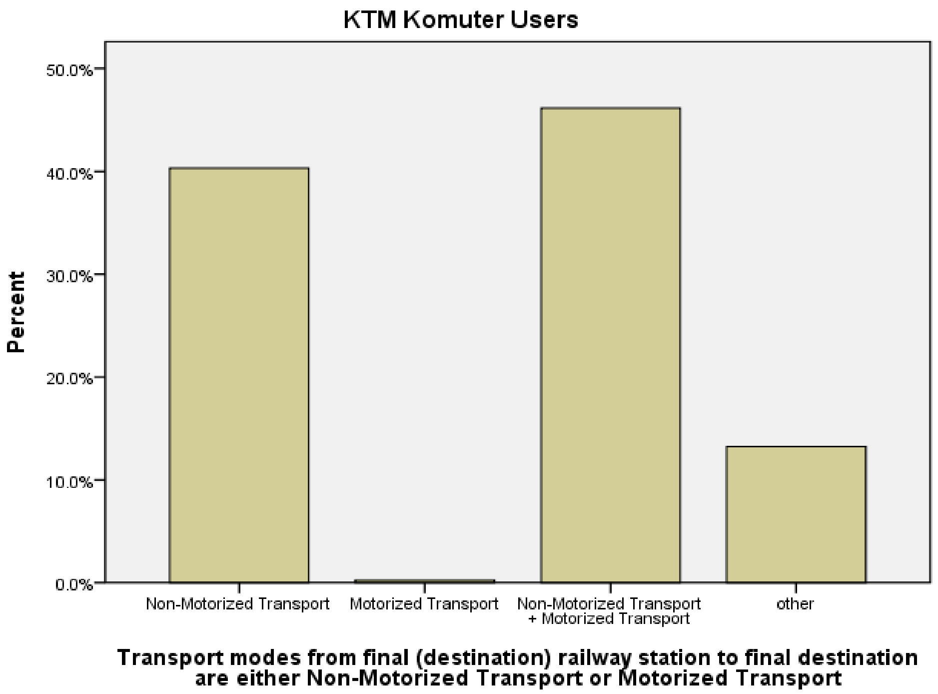
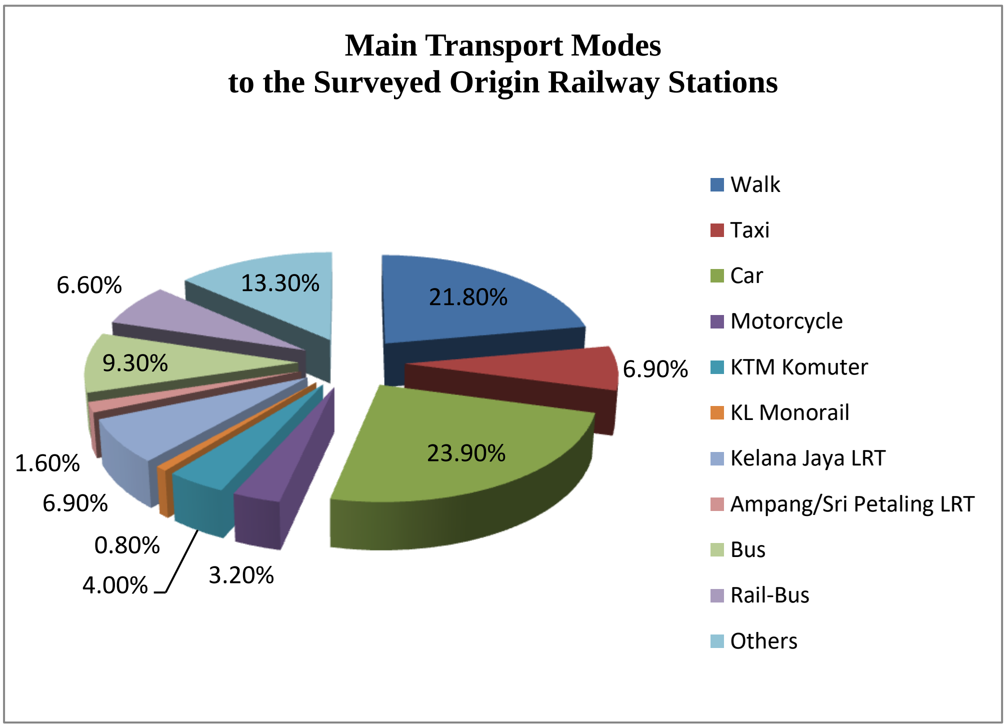


Figure 6.9 Non-Motorized and Motorized Transport, its Combination and Other Forms of Transport to the Origin Railway Stations and from the Final Railway Stations to Final Destinations



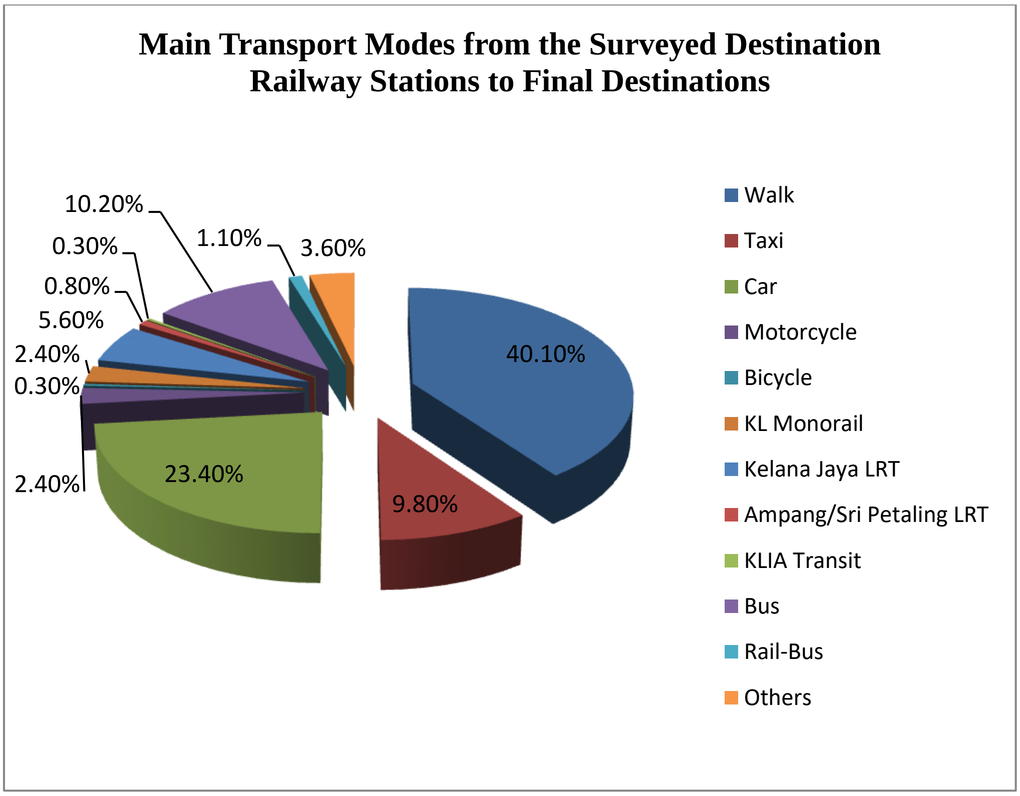
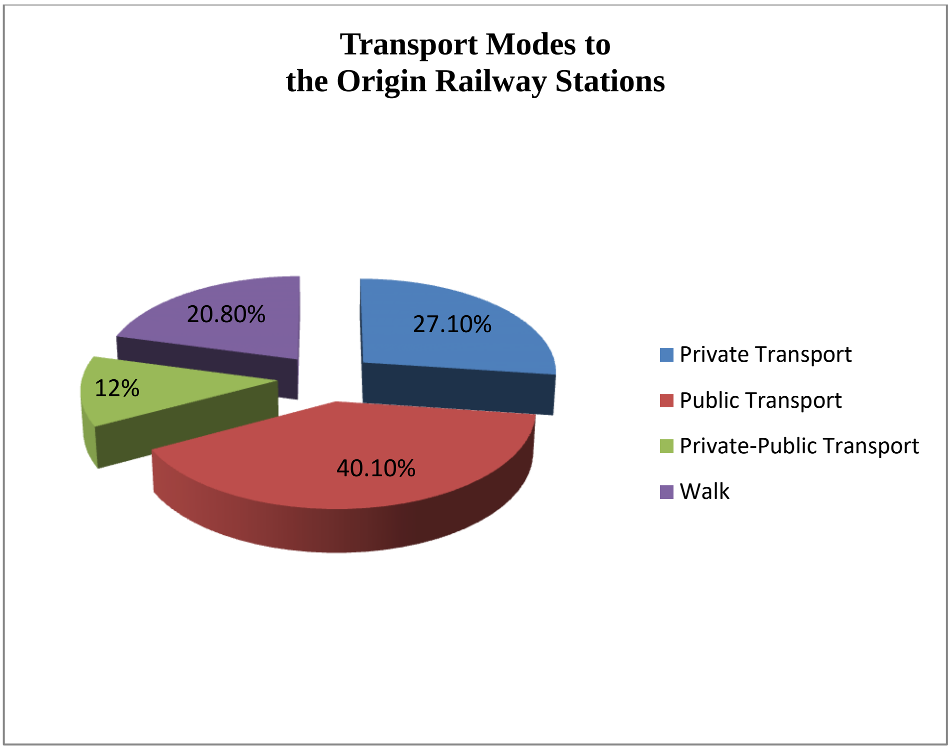


Figure 6.10 Modal Choices (%) to the Origin Railway Stations and from the Final Railway Stations to Final Destinations

Figure 6.11 showcases the percentages of *KTM Komuter* users who used public transport to and from the surveyed origin and destination railway stations. They were 40.1% and 32.2%, respectively. These percentages are very surprising because this shows that the government has made efforts to achieve its national target through the Ninth Malaysia Plan of which is to encourage public transport use among the citizens. Here, the KL public transport and private transport modal split for the end of the national plan is around 30:70 (The Economic Planning Unit, 2010). Simultaneously, the modal split surveys also managed to explore a term called private-public transport. From Figure 6.11, it can be seen that private-public transports were estimated at 12.0% and 2.4% to and from the surveyed railway stations, respectively. Of the 12.0%, they ranged the following modes of travel: car-bus, car-express bus, car-*KTM Komuter*, car-Ampang/Sri Petaling LRT, car-KLIA Transit, car-Kelana Jaya LRT, motorcycle-Kelana Jaya LRT, motorcycle-*KTM Komuter*, and motorcycle-bus-Kelana Jaya LRT. A small fraction of private-public transport to final destinations utilised transport via car-Ampang/Sri Petaling LRT, car-KLIA Transit, car-Kelana Jaya LRT, car-*KTM* Shuttle train, car-express bus, car-*KTM* Electric Train Shuttle, motorcycle-Kelana Jaya LRT, and motorcycle-bus.



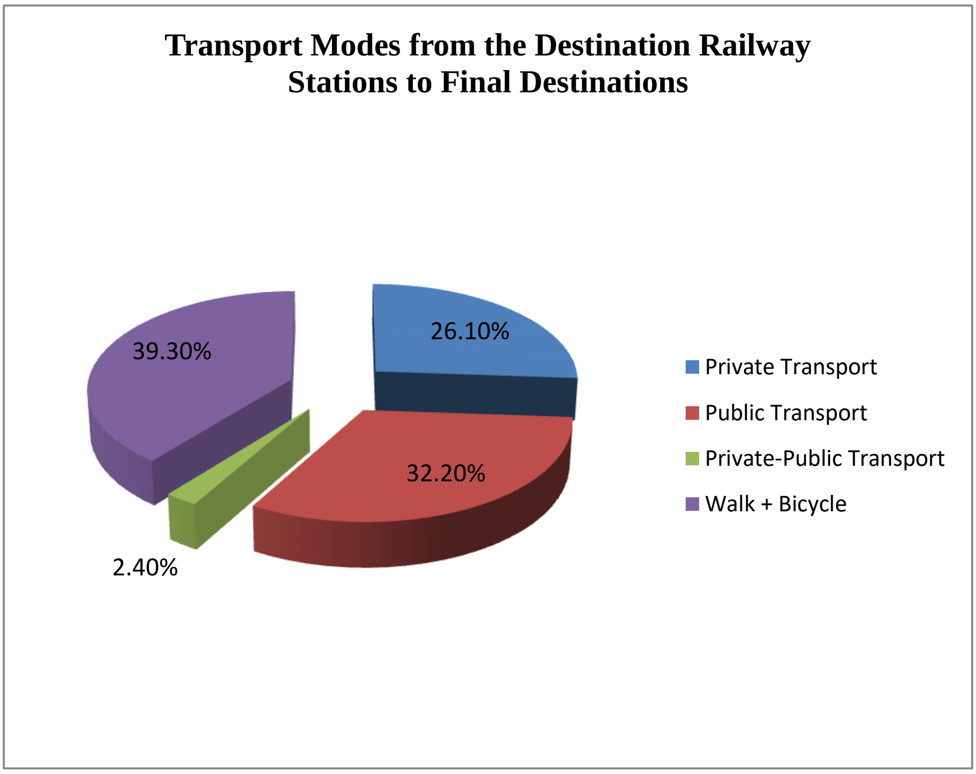


Figure 6.11 Private, Public and Private-Public Transport (%) to the Surveyed Origin Railway Stations and from the Surveyed Final Railway Stations to Final Destinations

An analysis into the use of motorized or road transport and NMT among *KTM Komuter* passengers explains the validity of the results of both the ownership of private vehicle(s) and car availability. 87.5% and 53.8% *KTM Komuter* passengers had great access to private vehicles and car trips, correspondingly. In contrast, the public transport captive riders surveyed were 47 (12.5%) with no private vehicles available for the trip and 51.1% of them involved females. Meanwhile, female users accounted for 111 users (63.8%) from the 174 (46.2%) of the *KTM Komuter* commuters who did not drive for the trip. These percentages coincide with the current ratio of KL public transport modal split to private transport, which is 12:88 as illustrated in Figure 2.15. This may be caused by poor condition of public transport vehicles, shortage of vehicle supply and the limited route (service) coverage of public transport, which also have been confirmed by (Syahriah et al., 2008; 2013). Based on Figure 2.15, after 2011, public transport usage will increase because of reliability even though many grouses for the inefficient public transport and traffic congestion occur. These will be within tolerable levels.

Further analysis depicts that 82 (21.8%) and 151 (40.1%) respondents had to use NMT or walk to complete their trips. The details can be seen on Figures 6.5 and 6.10. 21.8% and 40.1% of walking trips marked that the railway stations are accessible on foot and more importantly their locations are within acceptable service coverage or rail-based public transport oriented development (PTOD) in the pedestrian catchment area (PCA) of rail stations. For rail-based TOD and planning, the guidelines for standard walk distance are 300 - 900 m in Canada with variation across cities, 800 m in Singapore; 400 m (5 minutes walk) is assumed equal to walking speed of 80 m/min to LRT stations and 800 m (10 minutes walk) to train stations gazetted by the Department of Transport, Queensland Government in

Brisbane in 1999 and 400 - 800 m in the United States or typically no more than 15 - 20 minutes of walking time in the China and Singapore context (Rastogi and Krishna Rao, 2003; Wibowo and Olszewski, 2005; Yigitcanlar et al., 2007; Yew, 2008; Moniruzzaman and Páez, 2012; Jiang et al., 2012; Zhao and Deng, 2013). Walking is worth being analyzed since Yew reviewed that it demarcates quality of life and how efficient the transportation is in a Singaporean's experience.

Interestingly, results of descriptive statistics show that both the mean walk time to the first stations and mean walk time from the final railway stations to the final destinations were estimated to be 10 minutes for the 377 cases and involved four types of transport namely Non-Motorized Transport (NMT), Motorized Transport (MT), its Combination i.e. (NMT – MT) and Other Forms of Transport (O). With reference to *KTM Komuter* passengers who travelled by foot to and from rail stations, the respective mean access - egress walking time was approximately 14 minutes and 12 minutes. Among the valid observations, 58.3% and 61.8% of the commuters who travelled on foot were female commuters who accessed to and egressed from rail stations. 83.3% and 81.6% of the commuters who walked were between the ages of 20 and 49 at both entrance and exit rail stations, out of 83.3%, 46.4% were between the ages of 20 and 29, 21.4% were in their 30's while 15.5% were in their 40's; out of 81.6%, 48.7% represented those in their 20's, 20.4% in their 30's and 12.5% of the commuters were in their 40's. 31.0% reported a household monthly income between RM1000 and RM1999, 19.0% had a household monthly income between RM2000 and RM2999, and 15.5% between RM500 and RM999 and between RM3000 and RM3999 to access rail stations whilst at exit of final rail stations, 33.6% reported a household monthly income between RM1000 and RM1999, 22.4% had a household monthly income between RM2000 and

RM2999, and 14.5% between RM500 and RM999. 74.7% of the commuters who walked to the origin rail stations had two (36.1%), three (18.1%) and five (20.5%) people (over fifteen years of age) living in the household, including the respondents whereas 70.5% who walked from the final rail stations had a family size of between two (26.2%) and four (19.5%) people of above fifteen years of age, including the respondents. The walk commuters' occupation who accessed – egressed to – from the rail stations were private staff (41.7%), general workers (15.5%) and students (14.3%) private staff (38.1%), government staff (16.4%) and students (14.5%) respectively. The respective status of employment depict that 76.2% of them were full time private staff, government staff, semi-government staff, a *KTMB* staff, professionals, general workers and personal business persons, 19.0% had no employment status because they were students, housewives, unemployed and a retiree, and 3.6% were part time personal businessman and general workers; 76.3% of them were full time private staff, government staff, semi-government staff, a *KTMB* shift worker, *KTMB* staff, professionals, general workers, self-employed and personal business persons, 18.4% consisted of students, housewives and those unemployed whilst 4.6% were part time personal businessman and businesswomen, private and professional staff, and a general worker (both at the entrance and exit of the rail stations).

Descriptive analysis indicated that the access walk time during the weekdays was 10 minutes (20.0%), 5 minutes (18.5%) and 15 minutes (12.3%) with 56.0% walking during the evening peak to the rail stations of origin. The breakdowns were 10 minutes (19.1%), 5 minutes (17.0%) and 15 minutes (14.9%); 69.0% and 23.8% walked during peak hours and inter-peak hours respectively, specifically 5 minutes (20.7%), 10 minutes (19.0%) and 15 minutes (13.8%) during peak hours; 75.0% of the commuters walked during sunny days whereas 21.4% walked during cloudy days and the walking time for sunny days was 10 minutes (20.6%), 5 minutes (15.9%) and 15 minutes (9.5%). Descriptive analysis indicated that the egress walk time during the weekdays was 5 minutes (30.1%), 10 minutes (23.6%) and 15 minutes (16.3%) with 25.0% of the commuters walking during the evening peak. The breakdowns were 10 minutes (39.5%), 5 minutes (28.9%) and 15 minutes (13.2%); 39.1% also walked for 10 minutes during the morning rush from the final rail stations to their destinations, 37.9% and 29.0% also walked during late comer and during the afternoon peak for 5 minutes at the exit rail stations to their destinations respectively and 20.7% were also found walking from the final rail stations for 15 minutes during the late comer period; 60.5% and 33.6% walked during peak hours and inter-peak hours respectively, specifically 10 minutes (32.6%), 5 minutes (26.1%) and 15 minutes (12.0%) during peak hours; 83.6% of the commuters walked during sunny days whereas 13.8% walked during cloudy days and the walk time for sunny days was 5 minutes (27.6%), 10 minutes (23.6%) and 15 minutes (15.7%).

Descriptive analysis resulted in the corresponding access - egress walk distances for the commuters who walked to and from the rail stations (0.892 km and 0.623 km). 46.4% and 21.4% of the commuters who walked were between the ages of 20 and 29 and of 30 and 39 at the entrance of the rail stations respectively. 15.5% of them were in their 40s. Among the highest frequencies for the access walk distances were 16.7% (0.300 km), 14.3% (0.350 km) and 10.7% (0.450 km). Of 58.3% and of 61.8% of the walk commuters 16.3% and about 9.6% and 10.6% of female commuters accessed to and egressed from rail stations for 300 m and 200 m and 450 m respectively. 19.2% of the 31.0% reported a household monthly income between RM1000 and RM1999, 25.0% out of 19.0% had a household monthly income between RM2000 and RM2999, and 7.7% out of 15.5% between RM500 and RM999 and roughly 15.4% out of 15.5% earned between RM3000 and RM3999. These involved those who accessed rail stations for 300 m. While at the exit of final rail stations to reach the final destination after walking for 0.200 km, 15.7% of 33.6% reported a household monthly income between RM1000 and RM1999, 5.9% of 22.4% had a household monthly income between RM2000 and RM2999, and 13.6% of 14.5% between RM500 and RM999. Meanwhile to reach the final destination after walking for 0.450 km, 3.9% of 33.6% reported a household monthly income between RM1000 and RM1999, 8.8% of 22.4% had a household monthly income between RM2000 and RM2999, and 13.6% of 14.5% between RM500 and RM999. 74.7% of the commuters who walked to the rail stations of origin had two (36.1%), three (18.1%) and five (20.5%) people (over fifteen years of age) living in the household, including the respondents in which 20.0% of 36.1%, 13.3% of 18.1% and 5.9% of 20.5% walked for 0.300 km. 70.5% who walked 450 m from the final rail stations had a family size of between two (10.3% of 26.2%) and four (13.8% of 19.5%) people of above fifteen years, including the respondents. The walk commuters' occupation who accessed – egressed to – from the rail stations for 300 m and 200 m were private staff (22.9% of 41.7%), general workers (7.7% of 15.5%), students (25.0% of 14.3%) private staff (13.8% of 38.1%), government staff (16.0% of 16.4%) and students (4.5% of 14.5%). 17.2% of 76.2% of full time private staff, government staff, semi-government staff, a *KTMB* staff, professionals, general workers and personal business persons walked 300 m to the rail stations of origin whilst of 10.3% of and 8.6% of 76.3% of full time private staff, government staff, semi-government staff, a *KTMB* shift worker, *KTMB* staff, professionals, general workers, self-employed and personal business persons egressed 200 m and 450 m from the final rail stations respectively.

Descriptive analysis indicated that the access walk distances during the weekdays were 300 m (18.5%), 350 m (10.8%) and 450 m (10.8%) with 56.0% who walked during the evening peak to the rail stations of origin. The breakdowns were 300 m (14.9% of 19.1%), 350 m (14.9% of 17.0%) and 450 m (10.6% of 14.9%); 69.0% and 23.8% walked during peak hours and inter-peak hours respectively, specifically 300 m (15.5%), 350 m (17.2%) and 450 m (8.6%) during peak hours; 75.0% of the commuters walked during sunny days whereas 21.4% walked during cloudy days and the walk distance for sunny days was 300 m (15.9% of 20.6%), 350 m (14.3% of 15.9%) and 450 m (12.7%). Descriptive analysis indicated that the egress walk distances during the weekdays were 200 m and 450 m (11.4% and 7.3%), 300 m (8.9%) and 50 m (7.3%) with 25.0% of the commuters walking during the evening peak. The breakdowns were 200 m (13.2%), 300 m (13.2%) and 50 m (2.6%); 13.0%, 13.8% and 13.2% walked 200 m during the morning rush, during the late comer period and during the evening rush from the final rail stations to their destinations respectively, 27.3% walked 450 m during early release exit from the rail stations to their destinations and 13.2% also were found walking 300 m from the final rail stations to their destinations during evening rush; 60.5% and 33.6% walked during peak hours and inter-peak hours respectively, specifically for 200 m and 300 m (9.8% and 8.7%) and 50 m (7.6%) during peak hours while 19.6% walked 450 m from the final rail stations during inter-peak hours; 83.6% of the commuters walked during sunny days, among them were 10.2% who walked 200 m and 450 m, 7.1% walked for 50 m egressing from the rail stations and 8.7% walked 300 m to reach their destinations whereas 14.3% walked 150 m and 9.5% walked 100 m, 200 m, 300 m, 350 m, 400 m and 450 m during cloudy days.

With regards to accessibility, the mean access travel time to the origin stations was around 35 minutes whilst the egress travel time was about 25 minutes. These access and egress times were quite high and most likely due to the slightly higher total in-vehicle times recorded that was, 24 minutes and 15 minutes, respectively. In general, access facilities should be improved in order to provide greater benefits for rail users (Brons et al., 2009; Moniruzzaman and Páez, 2012). The respective travel distances and costs were found to be sensible with the total travel time spent. On average respondents had to spend about RM3.35 (£0.69) to reach the stations of origin and only RM2.73 (£0.56) to get to their final destinations. Judging the results of mean travel distances to and from railway stations for the 377 cases, these values of 13.6 km and 8.7 km strongly conclude the substantial number of stages happening within the access and egress trips and thus, the common use of mixed transport. From accessibility standpoint, such distances were interesting empirical evidence which contradict very much the 2-kilometre radius coverage of the rail services and the feeder buses for proximity of rail stations.

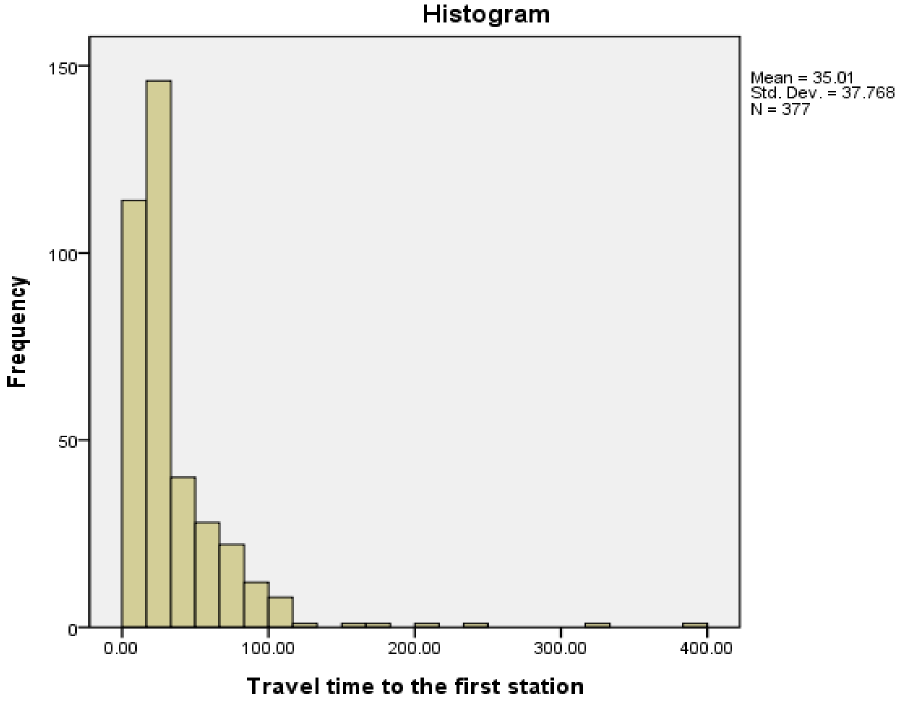


Figure 6.12 Average *KTM Komuter* access travel time

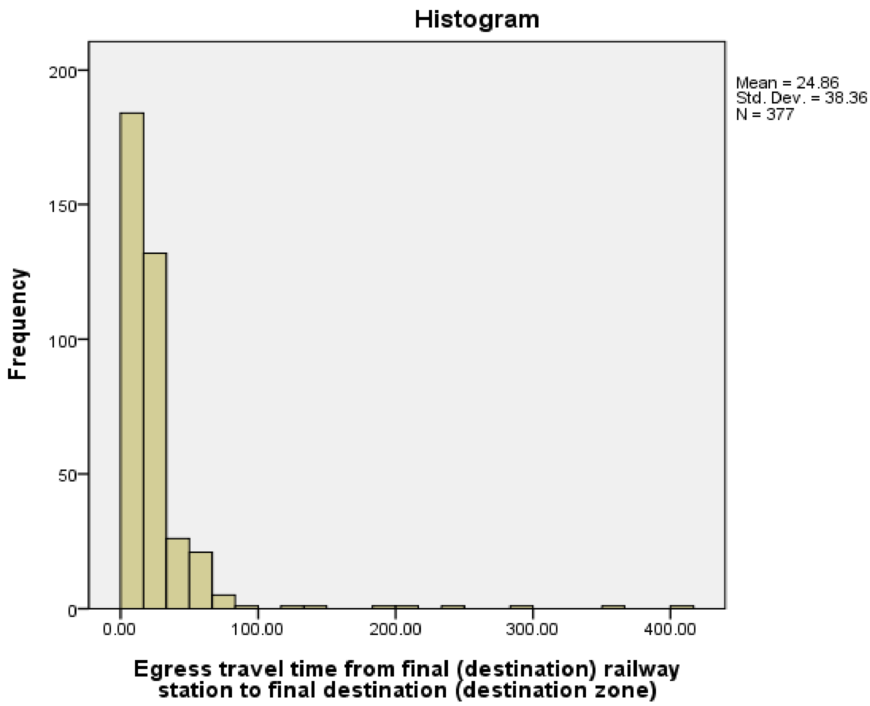


Figure 6.13 Average *KTM Komuter* egress travel time

According to this buffer-distance fix at the national planning level, the government already knew that the current rail systems were far problematic in terms of accessibility and connectivity compared to bus systems and this has been the causal factor for the poor capability of the rail operators to service the general public (Kuala Lumpur City Hall, 2005). Román and Martín (2011) also reported on a similar issue with the intermodal connectivity in Spain. On top of that, many individuals who lived or worked within that distance had not benefited from the *KTM Komuter* services in the study areas (Shamsul, 2008) and this resulted in the Kuala Lumpur City Hall initially planning for feeder services in 1996 and then appointing a local transport consultant by the government to handle a 5-kilometre feeder route length with 400 metres to be the radius of route catchment coverage from the bus-rail integration stations (BRIS) in 2003. Therefore, the topical results of access-egress distances proved that even the 5-kilometre feeder route length was unserviceable to ensure sufficient accessibility and to facilitate public transport availability and connectivity. The relative feeder route length should be tripled (i.e., 15.0 kilometres) to that of the results of studies done in 2002 to address the continuing limited coverage of *KTM Komuter* services.

From Figure 6.14, it can be noted that the average journey time on *KTM Komuter* was estimated to be 38 minutes. The dispersion of the journey time was from a minimum of three minutes to a maximum of one hundred and forty six minutes. Three minutes was analyzed as the minimum journey time because it proved that KL and Mid Valley were among the most frequently reported destined locations from the nearest railway station such as KLS. Whilst the maximum ones marked the non-home journey made by a housewife (Malaysian) from Seremban to Pelabuhan Kelang with excessive transfer times of 99.0 minutes at three transfer stations and seven stages to reach Pelabuhan Kelang. The main conclusion is that the waiting time for the connecting bus and/or rail system had actually contributed to the crucial consequence of a very long uncertain total multimodal travel time due to its role as part of the transferring process between the main intermodal stations for the variety of bus and rail systems' services. Users' experience of losing patience, feeling tired, frustration and stressed intensified (Yang et al., 2010, Nor Diana, 2012) even more with unreliable train operations yielding direct affects to the varied capacity utilization of the coaches and platforms in the absence of adequate electric multiple units (EMU) and its coaches (Goverde, 2005) during peak hours (Nor Diana, 2012). In view of that, the analysis on in-vehicle time, user waiting time and journey time due to additional users must be taken into consideration in the design of better *KTM Komuter* services (Larrain and Muñoz, 2008, Hu et al., 2008, Huang and Niu, 2012). This also implies that more new rolling stock are required to accommodate the current rolling stock capacity so as to significantly improve the overall operations as recommended by Huisman et al. (2005). It provides evidence supporting the previously defined research hypotheses under Section 1.5 of increasing public transport vehicles, especially rail cars/coaches or set of trains in addition to the type of commuter trains.

On average, the journey time from Pelabuhan Kelang to Sentul and vice versa took 83.0 minutes and this was considered a transfer-free connection. This also indicated that service frequency and schedule needed immediate attention due to high headways or time intervals between trains and arrival times of trains being ahead of schedule (Khan and Zhou, 2010). Additionally, the overall performance rating of the journey time results can be concluded to have been penalized by passengers' individual behaviours which have led to longer journey times. This has something to do with the improvement of *KTM Komuter's* LOS or efficiency in terms of travel time and different passenger distribution over the commuter trains (Takagi et al., 2006, van Oort and van Nes, 2010) or transfer time to change transport modes (Macário, 2010). The current service frequency or headway should be conservatively reduced to less than 15 minutes or optimally designed to be 5 minutes as proposed for the national public transport integration strategy. *KTMB* also does not have sufficient train coaches and full train sets. Concurrently, there is a high *KTM Komuter* ridership and likewise, a high demand from the users at each O-D station and the preceding travel time unreliability of the passenger trains generates substantial numbers of train delays (Khan and Zhou, 2010) without any prior notice, particularly during the peak hours of the weekdays and over the weekends. This unexpected overwhelming demand and operation technical faults have brought about increases in the load (crowding) levels (Nor Diana, 2012) and uncertainty about the trips at both the station platforms and on the train coaches (Syahriah et al., 2013; Transportation Research Board, 2013), particularly congestion at doors (Harmize, 2008, Hirsch and Thompson, 2011, van Oort and van Nes, 2010, Takagi et al., 2006) and longer waiting time (O'Dell and Wilson, 1997), and the inconvenience of use. So, the current service frequency and schedule such as between 15 minutes and 20 minutes during peak hours whereas 30 minutes during inter-peak and off-peak hours no longer serve the users in a comfortable manner. As such, passengers will suffer an average waiting time of between 5 and 15 minutes in a theoretical manner (Syahriah et al., 2013). In other words, the current service frequency does not reflect the convenience of the timetable to passengers (Douglas and Karpouzis, 2009). In contrast Su Shen and Wilson (2001) comment that the common operational disturbances faced by *KTM Komuter* took more than 20 minutes to recover and it was extremely discouraging when the headways were beyond half an hour and more than two hours waiting time as an empirical evidence of Syahriah et al.'s (2013) research. Consequently, passengers had to wait long because the mean waiting time was roughly 17.5 minutes. From 2008, this proved that changes in capacity and frequency have principally and persistently affected the passenger waiting times (Larsen and Sunde, 2008, Gallo et al., 2011, Syahriah et al., 2013). Since there is no site observations on the actual *KTM Komuter* service frequency, the actual frequency has been predicted according to the designated mean waiting time of 2.5 minutes and frequency of 5 minutes for the proposed public transport integration strategy in the KL urban-suburban areas to test the corresponding frequency for the mean waiting time of 17.5 minutes for these O-D surveys. It was found that the users had been waiting for about 17.5 minutes for the arrival of the next connecting train for a frequency (headway) of 35 minutes. So, wait time is more than half the scheduled headway because of unreliability. Figure 6.15 depicts the waiting time for the *KTM Komuter*. This result sounds logical as 61.0% data were recorded during peak periods whereas 32.0% described the inter-peaks periods. It could also realistically represent the current service frequency that is between 15 and 20 minutes during peak hours and 30 minutes during inter-peak and off-peak hours.

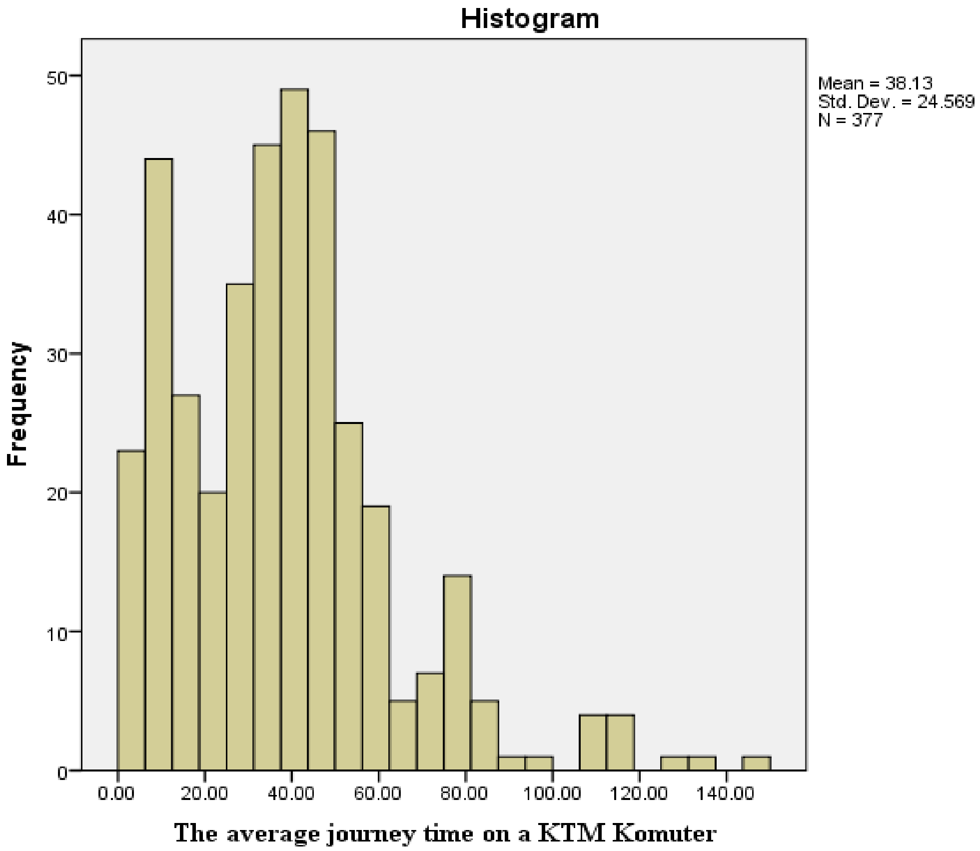


Figure 6.14 Average *KTM Komuter* journey time

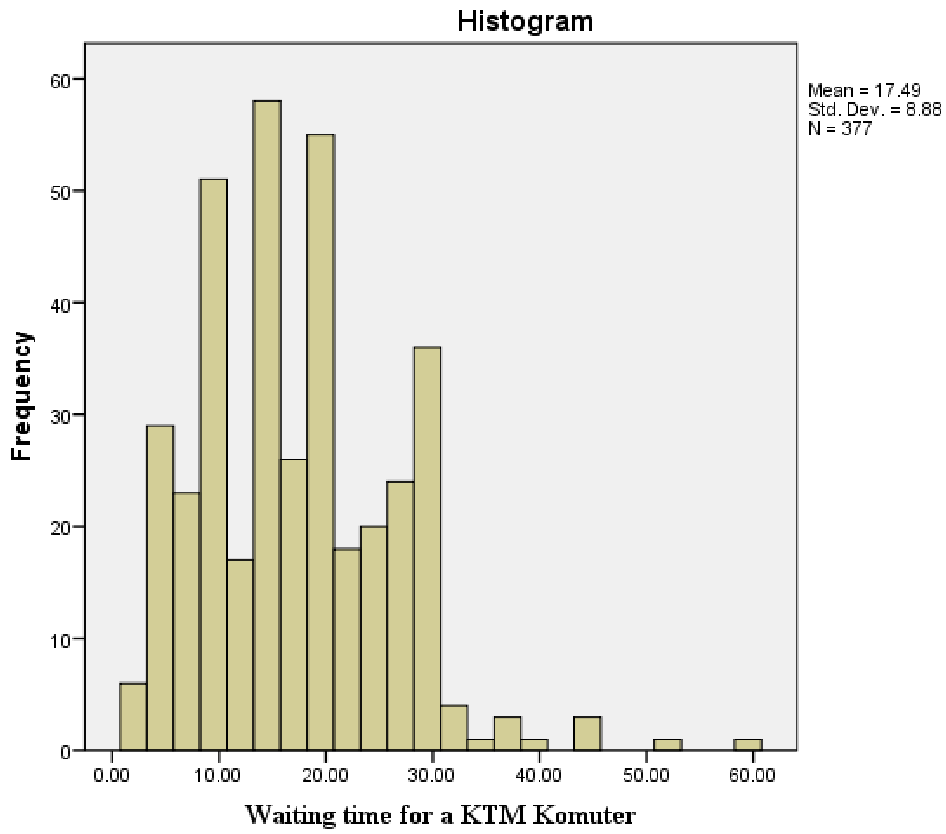


Figure 6.15 Waiting time for a *KTM Komuter*

The surveys reported on average that *KTM Komuter* fare was RM3.60 (£0.66) taking into consideration the number of accompanied person. 62.9% of the users were satisfied with the fare structure. About 95.0% of the passengers were in the fare category of adult and no more than 2.0% were categorised as senior citizens and adults accompanied by children. As high as 69.2% of the passengers bought single adult tickets, approximately 12.0% of them were categorised as return adult tickets and 0.8% were in the ticket types of single and return adult and children aged 4-11. The frequency analysis of quantity of tickets for *KTM Komuter* ride resulted in 66.8% of the passengers being one adult, followed by two adults (7.7%) and 4.5% consisted of more than two adults. 58.4% of the users bought tickets at the counters.

20.4% used Ticket Vending Machines and 13.0% used magnetic-stripe tickets as types of payment for the *KTM Komuter* ride. Only 4.5% paid for the services using a monthly pass. There was such response as none being as many as 1.6% for fare category, 15.1% for type of tickets used and 19.9% for quantity of tickets for *KTM Komuter* trip due to no information or answers obtained from the respondents or missing or left blank answers.

Based on the Passenger Demand Forecasting Handbook (PDFH) (2002), the average journey time is 115.5 minutes and the average journey cost is RM9.71 (Siti Nurbaya et al., 2013) as can be seen in the Tables 6.1 and 6.2.

Table 6.1 The Calculation for A Total Average Journey Time

Average Journey Time	Mean (Standard Deviation)
Average Access Travel Time	35.0 minutes (37.8)
Average Wait Time	17.5 minutes (8.9)
Average Ride Time	38.1 minutes (24.6)
Average Egress Travel Time	24.9 minutes (38.4)
Total Average Journey Time	115.5 minutes (109.7)

Table 6.2 The Calculation for A Total Average Journey Cost

Average Journey Cost	Mean (Standard Deviation)
Average Access Travel Cost	RM3.35 (5.10)
Average Ride Cost	RM3.63 (3.61)
Average Egress Travel Cost	RM2.73 (7.14)
Total Average Journey Cost	RM9.71 (15.85)

Passenger profile is presented in next section to assess the sample quality collected in the *KTM Komuter* system.

6.4 CHARACTERISTICS OF *KTM KOMUTER* USERS

Figure 6.16 presents the age group split among the users of the *KTM Komuter*. A review on the demographic profile has resulted in the largest group of users that is 189 or 50.1% being within the ages of 20 and 29 years old. The second largest group totalled 86 persons (22.8%) in their 30s. Only 37 users (9.8%) represented the age group of 40s. 91.5% represented adults with no restriction covering ages from 20 years to 64 years. To sum up, the respondent pool was of an average age of between 20 and 39 years, with a minimum being less than 20 years and the maximum being between 65 years and above. Some 86.7% of the sample travelled alone waiting for the arriving trains at the stations of origin while some 86.5% of the sample were travelling without accompanied persons at the final stations.

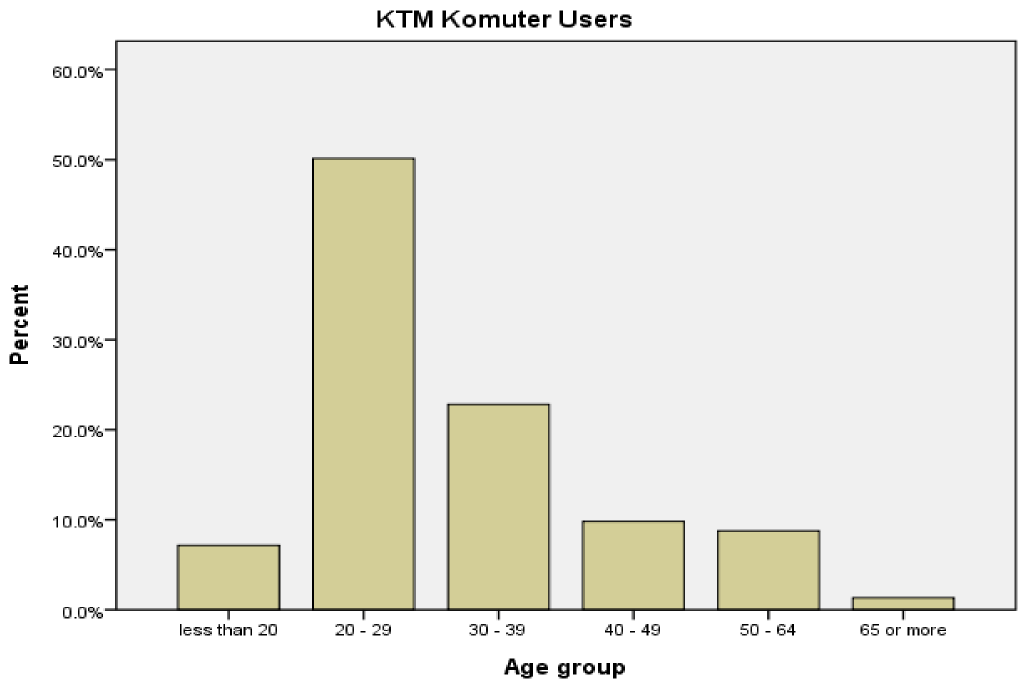


Figure 6.16 Age Group Split

From Figure 4.10 under Subheading 4.3 of the thesis, KL's population in 1991 and 2000 for age group between 20 and 29 was estimated at 22.4% and 21.9%, correspondingly. Also, the Klang Valley had a population of 22.6% and 21.6% for the same period and age group. City age structure in 2000 can be broken down into the following: below 27.0%, teenagers under 15 years old while 67.0% represented those in the 15-59 age group. Only 6.0% of the KL residents were elderly persons (Kuala Lumpur City Hall, 2005b).

The estimated total population of KL and Malaysia in 2010 was 1.68 million and 28.25 million, respectively. The details for the 2010 data ranged for those in the age groups of below 20, 20 – 29, 30 – 39, 40 – 49 to 65 – 95 and above with a respective value of 38.0%, 12.9%, 17.9%, 13.9% and 4.6%. Similarly, the details for Selangor's 2010 data ranged for individuals being from the age groups of below 20, 20 – 29, 30 – 39, 40 – 49 to 65 – 95 and above with a respective value of 39.5%, 15.4%, 16.8%, 13.5% and 3.4% out of 5.29 million (MalaysiaEconomy, 2010). Therefore, the ratio of *KTM Komuter* users between 20 and 29 years old to the population in KL and Selangor was 3.88 and 3.25, respectively whereas the other ratios remained constant.

Figure 6.17 depicts that 14.6% were parent(s) with small children. 19.4% were those in special groups and these special groups included pregnant women, disabled persons, elderly persons and wheelchair-bound individuals. It can be concluded that about 73.0% were adults with no guardians, and who had physical and disability restrictions. The adults accounted for 91.5%. The ages of the adult *KTM Komuter* users ranged from 20 years to 64 years old. It was evident that a very small percentage of senior citizens i.e., 1.3% used the *KTM Komuter*. The small proportion of this user group probably attributed to some of the pedestrian bridges and staircases, and the transfer facilities that were deemed inconvenient. This group did not need regular travel due to their physical limitations and limited personal affairs. Only 4.8% of the users were adults such as pregnant women, disabled persons, elderly persons and wheelchair bound users owing to the pertinent provision of services and facilities being poor in quality. Some of them requested for convenient, special user-friendly and priority accessible services. For example, a-37 year male wheelchair bound user had to call the *KTMB* officer up every time he took the *KTM* Shuttle from Kuala Kubu Bharu to Batu Tiga for his work trip because the shuttle train had to change to the connecting *KTM Komuter* at the correct platform at the Rawang transfer station only for him. This was because the platform did not have a lift to enable him to change platforms on his own. However, he admitted that the staff were very helpful and friendly and that he was very satisfied with the current fares for the disabled. This wheelchair-bound user is a good example of a truly regular user.

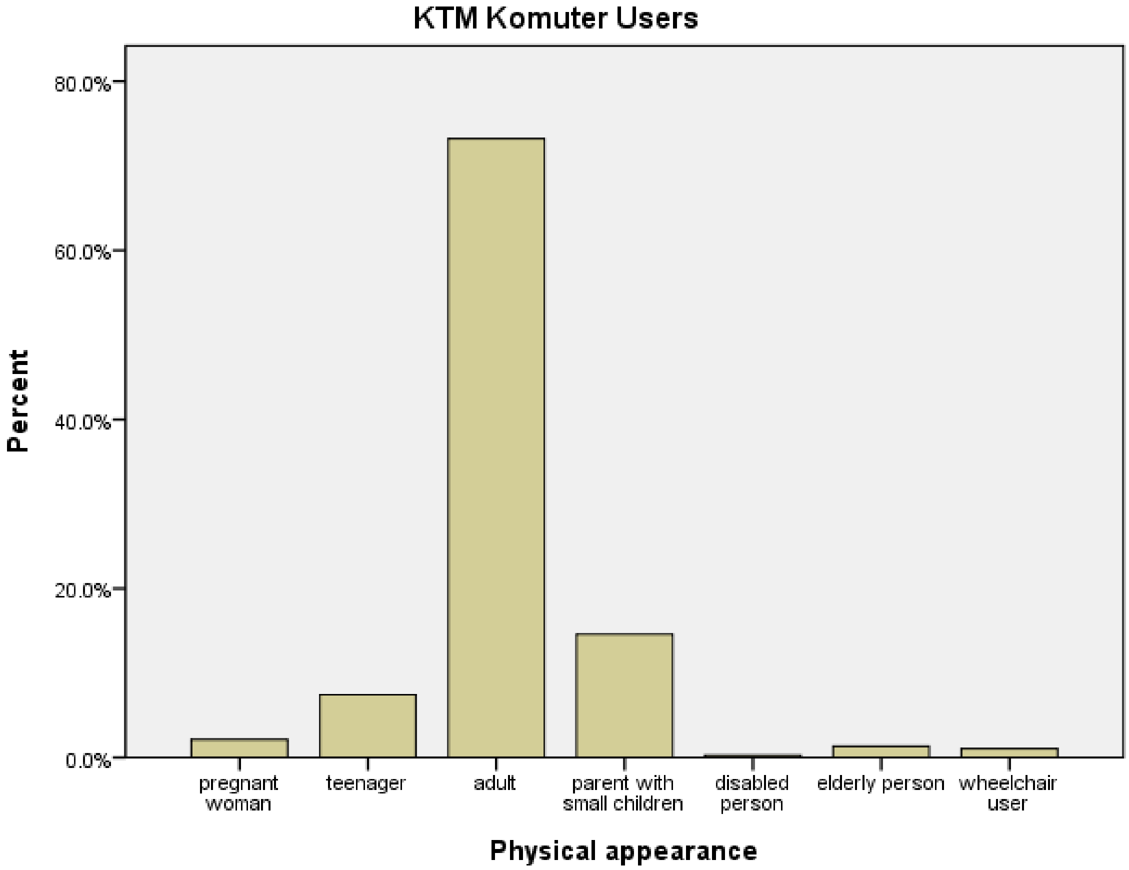


Figure 6.17 Physical Appearance of *KTM Komuter* Users

Figure 6.18 shows the gender among the *KTM Komuter* users. It is evident that women riders were the dominant users with 241 persons (63.9%) in comparison to the men. Figure 4.9 shows that there were approximately 49.5% females in the KL population and 49.2% females in the Klang Valley in 2000. Figure 4.9 can be seen under Subheading 4.3 of the thesis.

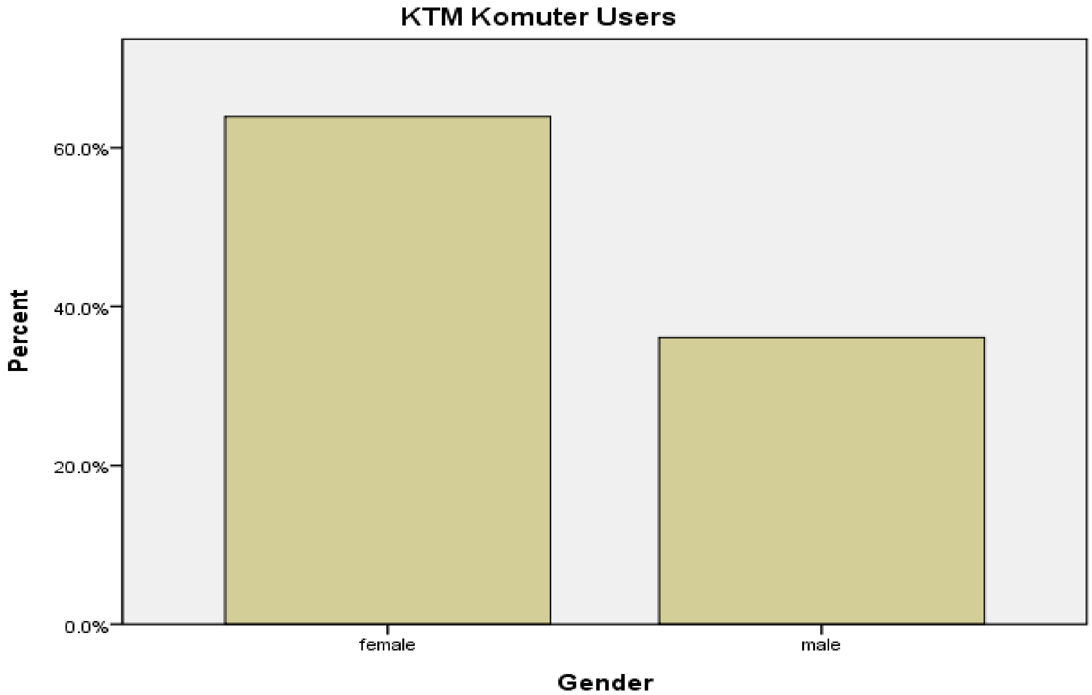


Figure 6.18 Gender Distribution

Recent gender data in 2010 for KL and Selangor groups depict age groups, that range from those below 20, 20 – 29, 30 – 39, 40 – 49 to 65 – 95 years old and above with a respective value for males being 38.7%, 13.1%, 17.3%, 13.8% and 4.3% and females ranging from 37.2%, 12.7%, 18.5%, 14.1% to 4.8% for KL residents; and those from Selangor included 40.2%, 15.2%, 16.6%, 13.3% and 3.2% for the males and 38.9%, 15.6%, 17.0%, 13.6% and 3.8% for the females. Of the estimated total population of KL in 2010, 49.4% were still females. For the same year, Selangor was populated by 48.9% females of the 5.29 million (MalaysiaEconomy, 2010). Comparatively, the ratios of *KTM Komuter* woman users to the total population in KL and Selangor stood at 1.30.

Overall, the KL population growth rate was slow due to high net out-migration of people in KL to the suburban areas i.e. from 17.1% to only 9.0% from 1980 to

2000. This was due to the enormous housing opportunities in the areas outside KL (Kuala Lumpur City Hall, 2005b). KL offered 58.0% employments from the sum of 838 400 employments in 2008 (Leong, 2010). At the national level, the recent unemployment rate was at 3.6% (Allyhunt, 2010).

Further analysis on the socioeconomic profile of the *KTM Komuter* users display that a majority of the users ranged from full time private staff with 161 individuals (42.7%) to 74 (19.6%) students to 43 (11.4%) full time staff from the government sector. Figure 6.19 shows the graphical form of occupation distribution. This could mean workers and students are expecting the best services of public transport.

179 (47.5%) of the *KTM Komuter* users were categorized in the low income group where they earned less than RM2000 (£412.02) per month.

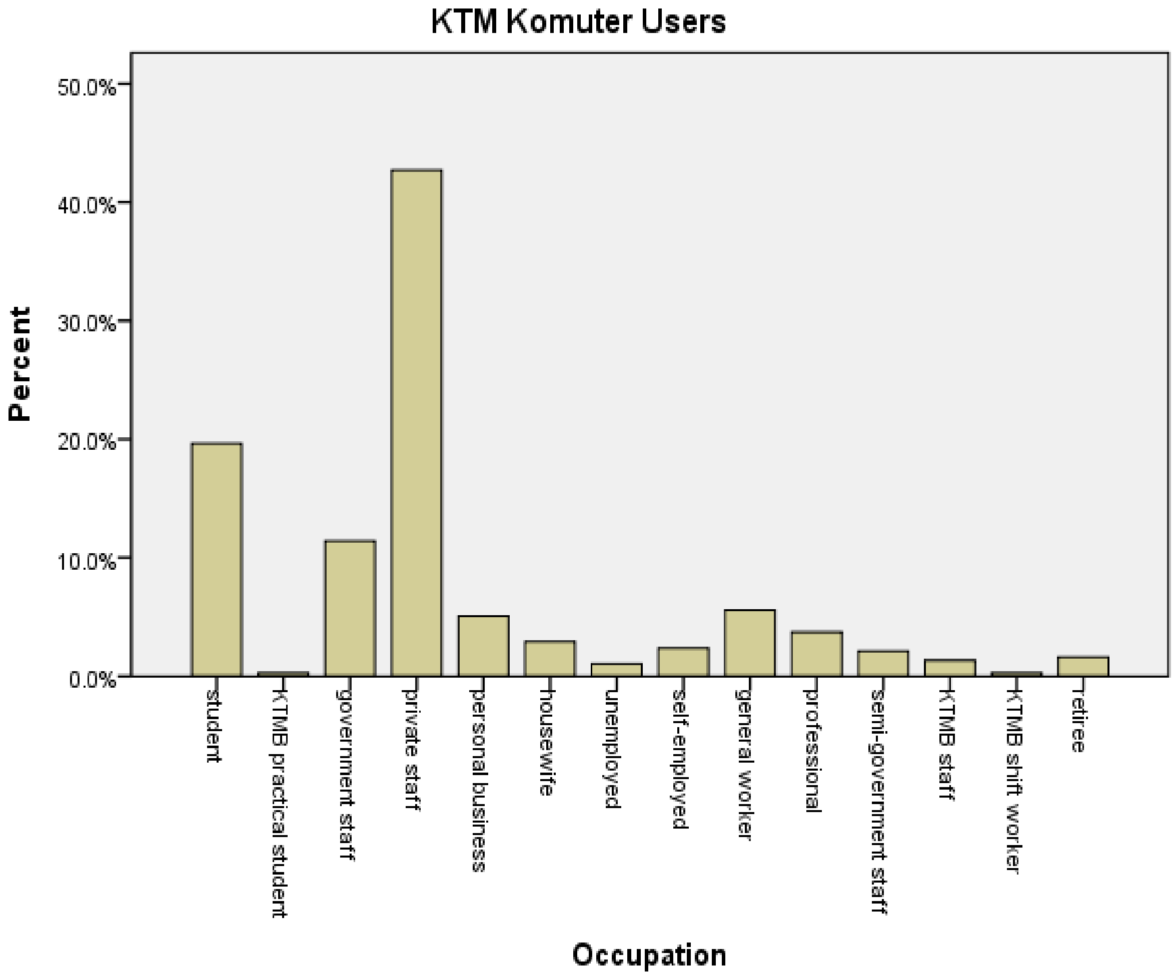


Figure 6.19 Occupation Distribution of *KTM Komuter* Users

Figure 6.20 indicates the monthly income distribution of the *KTM Komuter* users. The largest group made up the RM1000 to RM1999 salary range (£206.01 - £411.81) (117, 31.0%). The group with a monthly income of RM2000 to RM2999 (£412.02 - £617.82) (71 or 18.8%) came second. The third group (44 or 11.7%) earned an income from RM500 to RM999 (£103.00 - £205.80) per month. 47.5% of the *KTM Komuter* users earned below RM2000 (£412.02). KL residents with a monthly income under RM1000 (£206.01) were categorized as the urban poor who could afford to buy low cost houses (Kuala Lumpur City Hall, 2005b). 62 (16.5%)

of the users were categorized as these urban poor. Based on 377 valid observations, the current service levels had a positive impact on the demand for *KTM Komuter* among the middle to low income groups. This is consistent with the high income group, who had a high propensity to use private vehicles in the city environments (Mackett et al., 2006). It is necessary to note that *KTM Komuter* was also the preferred mode of travel among the users with a monthly income in excess of RM3000 (£618.02). They were 77 (20.4%) out of the total 377 *KTM Komuter* users.

The KTM Komuter users largely comprised of young (age group of between 20 and 29) full time private staff, adults, females, at least one private vehicle owner (≥ 32.8%) and mainly i.e. 61.5% from low income group of monthly income between RM1000 (£206.01) and .RM1999 (£411.81) and has car availability for KTM Komuter trip. Overall, 53.9% of the KTM Komuter users were female of age group between 16 and 39 with monthly income of less than RM3000 (£618.02) and has car availability for this KTM Komuter trip. The main trip purposes for this trip were going home and from normal workplace and going home. So, they were home-based trips. Findings by Azimah (2015) on the profile of typical public transport users in Klang Valley corroborate the results found in this study. Based on this result, it is reasonable to believe that people are being persuaded to use KTM Komuter because they have limited financial resources necessary to support private vehicle ownership and use.

The travel behaviour of these high income groups were explored further via empirical analysis and cross tabulation of the related questionnaire data such as access and egress modal choices by monthly income categories, main trip purposes by monthly income categories, and trip frequency by monthly income categories.

Tables 6.3 and 6.4 show that the users with a monthly income of between RM3000 (£618.02) and RM3999 (£823.83) and RM4000 (£824.04) and above contributed to about one tenth to the total multimodal trips. Tables 6.5 and 6.6 are simplified tables as a result of cross tabulation analyses. Table 6.5 summarizes that daily users comprised 32 users with a monthly income of between RM3000 (£618.02) and RM3999 (£823.83) whereas 30 users represented the monthly income group of RM4000 (£824.04) or more, thereby the sum was 62 (80.5%). Table 6.6 is another evidence of users with a monthly income in excess of RM3000 (£618.02). These individuals contributed to daily travelling using *KTM Komuter* at 62.3% (48 out of 77 users). None refers to 50 users (13.3%) with no monthly income.

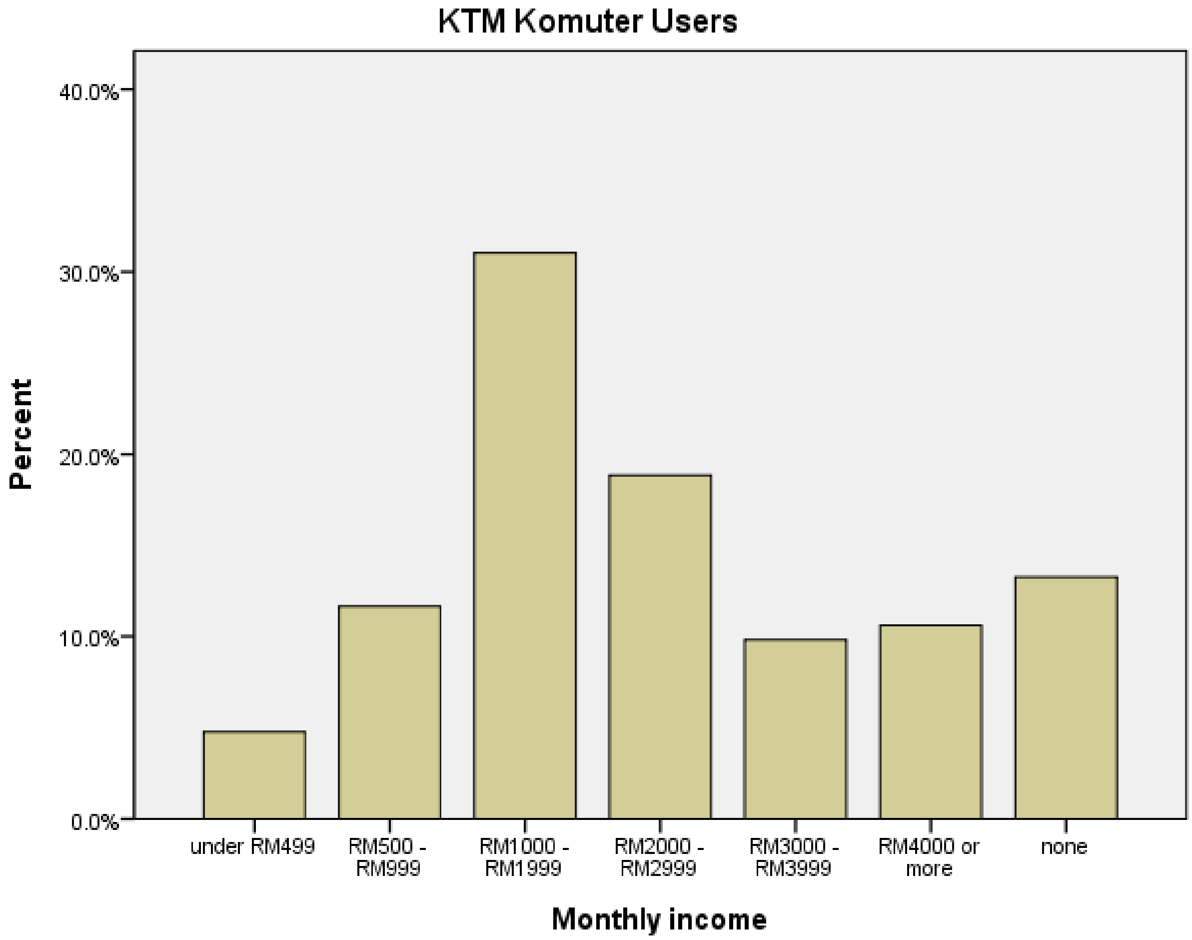


Figure 6.20 Monthly Income Distribution of *KTM Komuter* users

Table 6.3 Access Modal Split by Monthly Income Groups

Monthly income * Transport modes to first (origin) railway station are either Non-Motorized Transport or Motorized Transport Crosstabulation

		Transport modes to first (origin) railway station are either NMT or MT				
Monthly income		NMT	MT	NMT + MT	Others	Total
under RM499		2	0	9	7	18
	%Within monthly income	11.1%	0.0%	50.0%	38.9%	100.0%
	%Within transport modes	2.4%	0.0%	5.5%	5.5%	4.8%
RM500 - RM999	%Within monthly income	29.5%	4.5%	34.1%	31.8%	100.0%
	%Within transport modes	15.9%	40.0%	9.2%	11.0%	11.7%
RM1000 - RM1999	%Within monthly income	22.2%	0.9%	41.9%	35.0%	100.0%
	%Within transport modes	31.7%	20.0%	30.1%	32.3%	31.0%
RM2000 - RM2999	%Within monthly income	22.5%	0.0%	46.5%	31.0%	100.0%
	%Within transport modes	19.5%	0.0%	20.2%	17.3%	18.8%
RM3000 - RM3999	%Within monthly income	35.1%	2.7%	29.7%	32.4%	100.0%
	%Within transport modes	15.9%	20.0%	6.7%	9.4%	9.8%
RM4000 or more	%Within monthly income	17.5%	0.0%	57.5%	25.0%	100.0%
	%Within transport modes	8.5%	0.0%	14.1%	7.9%	10.6%
none	%Within monthly income	10.0%	2.0%	46.0%	42.0%	100.0%
	%Within transport modes	6.1%	20.0%	14.1%	16.5%	13.3%
% within Monthly income	Total (%)	21.8%	1.3%	43.2%	33.7%	100.0%
% within Transport modes to first (origin) railway station are either NMT or MT		100.0%	100.0%	100.0%	100.0%	100.0%

Table 6.4 Egress Modal Split by Monthly Income Groups

Crosstabulation(Monthly income * Transport modes from final railway station to final destination are either Non-Motorized Transport or Motorized Transport)

		Transport modes from final (destination) railway station to final destination are either NMT or MT				
Monthly income		NMT	MT	NMT + MT	Others	Total
under RM499	Count	8	0	7	3	18
	% within Monthly income	44.40%	0.00%	38.90%	16.70%	100.00%
	% within Transport modes	5.30%	0.00%	4.00%	6.00%	4.80%
RM500 - RM999	Count	22	0	16	6	44
	% within Monthly income	50.00%	0.00%	36.40%	13.60%	100.00%
	% within Transport modes	14.50%	0.00%	9.20%	12.00%	11.70%
RM1000 - RM1999	Count	51	1	53	12	117
	% within Monthly income	43.60%	0.90%	45.30%	10.30%	100.00%
	% within Transport modes	33.60%	100.00%	30.50%	24.00%	31.00%
RM2000 - RM2999	Count	34	0	31	6	71
	% within Monthly income	47.90%	0.00%	43.70%	8.50%	100.00%
	% within Transport modes	22.40%	0.00%	17.80%	12.00%	18.80%

Table 6.4 continued

RM3000 - RM3999	Count	9	0	23	5	37
	% within Monthly income	24.30%	0.00%	62.20%	13.50%	100.00%
	% within Transport modes	5.90%	0.00%	13.20%	10.00%	9.80%
RM4000 or more	Count	14	0	17	9	40
	% within Monthly income	35.00%	0.00%	42.50%	22.50%	100.00%
	% within Transport modes	9.20%	0.00%	9.80%	18.00%	10.60%
none	Count	14	0	27	9	50
	% within Monthly income	28.00%	0.00%	54.00%	18.00%	100.00%
	% within Transport modes	9.20%	0.00%	15.50%	18.00%	13.30%
Total	Count	152	1	174	50	377
	% within Monthly income	40.30%	0.30%	46.20%	13.30%	100.00%
	% within Transport modes from final (destination) railway station to final destination are either NMT or MT	100.00%	100.00%	100.00%	100.00%	100.00%

Table 6.5 Main Trip Purposes and Monthly Income Groups

Monthly Income Groups	**Work Trip**	**Home Trip**	**Total Trips**
RM3000 – RM3999 (£618.02 - £823.83)	24	8	32
RM4000 and above (£824.04 and above)	29	1	30

Table 6.6 Frequency of Trips and Monthly Income Category

Monthly Income Groups	**5 or more days a week**	**2 – 4 days a week**	**2 – 4 days a week (daytime), 1 – 3 times a month (nighttime)**	**Many times**	**5 times a month**	**4 times a month**	**Total Frequency**
RM3000 – RM3999 (£618.02 - £823.83)	22	5	0	0	0	1	28
RM4000 and above (£824.04 and above)	11	5	0	0	0	4	20

6.5 DETAILED ANALYSIS OF THE O-D RESULTS

6.5.1 Calculations of the Generalised Journey Time (GJT)

Total weighted travel time was calculated using the following formula recommended by Preston (2012b) in Microsoft Excel:

$$T_c = T_i + T_o w_o + bI;$$

where,

T_i = in-vehicle time;

T_o = out-of-vehicle time;

I = number of interchanges;

w_o and b = 'penalties' which convert the components into equivalent amounts of journey time; w_o is a weight, which is often taken as 2 (Preston, 2012b);

GJT was calculated using the following formula recommended by Crockett et al. (2004) in Microsoft Excel:

$$GJT = T_u + aH + bI;$$

where,

T_u = total unweighted travel time;

H = service headway;

I = number of interchanges;

a and b = 'penalties' which convert the components into equivalent amounts of journey time.

The *KTM Komuter* services were considered frequent services. With reference to Chapter B3, page 43, *b* reasonably considers the associated walking and waiting time, with a small additional 'hassle' factor (Passenger Demand Forecasting Handbook: The Association of Train Operating Companies, 2002). With reference to Chapter B3, page 43, for interchanges involving frequent or unscheduled services, the interchange penalty should be taken as 5 minutes, and will include walking time at the interchange station, and the average waiting time for onward trains. However, the interchange penalty, b should be considered as the transfer (interchange) time at stations for frequent services in the calculations or in the spreadsheet of Microsoft Excel.

Result of the Calculations of the GJT (Siti Nurbaya et al., 2013) is as follows:

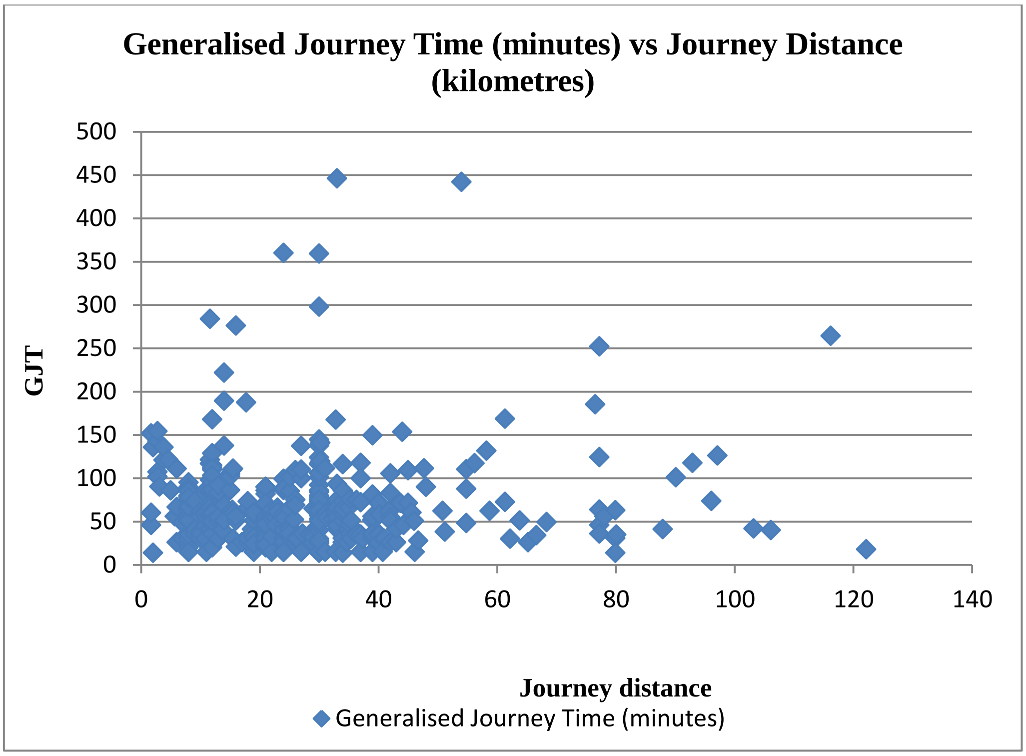


Figure 6.21 GJT in minutes vs Journey Distance (kilometres)

. This scatter would generate a spurious high correlation because of the effect of the other data points called outliers. On average, the respondents had experienced GJT of 69.38 minutes with a standard deviation of 55.751 The GJT values were between 14 and 446 minutes. This meant the resulting values of GJT were moderate compared to the corresponding journey distances. Only 3.98% (i.e. 15 data points) of the 377 respondents travelled of more than 150 minutes for the GJT. This high GJT was mostly contributed by a high amount of total unweighted travel times. The total unweighted travel times were the summation of in-vehicle time and the actual time spent on interchanging or transferring.

6.5.2 Calculations of the Generalised Travel Cost (GTC)

We assume that the average cost is borne entirely by the user and this is sometimes labelled generalized cost. It indicates the monetary value of the resources supplied by an individual taking a trip (Small and Verhoef, 2007). Kumar et al. (2004) and Lai and Chen (2011) highlighted generalized cost as an estimation of the total disutility of travel. Nash (1982) and Hartley and Nash (1980) have expressed another view. Nash has drawn attention to the fact that 'as a way of combining time and cost, the notion of GTC is frequently used, whereby time and cost are expressed in common units by attaching a money value to journey time (with usually a higher value for walking and waiting time than for in-vehicle time)'. Hartley and Nash viewed GTC as representing trip characteristics of public transport namely fares, in-vehicle time, and walking and waiting time (both weighted relative to in-vehicle time). Generalised cost is also an overall trip cost based on (Crozet, 2005) and in transport economics, it is the sum of monetary and non-monetary costs of a journey. Monetary (or 'out-of-pocket') costs might include a fare on a public transport journey, or the costs of fuel, wear and tear and any parking charge, toll or congestion charge on a journey by car. Non-monetary costs on the other hand, refer to the time spent undertaking the journey. Time is converted to a money value using a value of time figure, which usually varies according to the traveller's income and the purpose of a trip.

GTC was calculated using the following formula recommended by Crockett et al. (2004) in Microsoft Excel:

$$GTC = a_1 t_{ij}^{v} + a_2 t_{ij}^{x} + a_3 t_{ij}^{w} + a_4 t_{nij} + a_5 F_{ij} + a_6 \phi_j + \delta;$$

where,

t_{ij}^{v} = in-vehicle time (IVT) for individual *i* in mode *j*;

t_{ij}^{x} = access time to and from stations;

t_{ij}^{w} = waiting time at stations;

t_{nij} = interchange time, if any;

F_{ij} = fare charged to travel;

ϕ_{j} = terminal cost;

δ = 'modal penalty' representing security, comfort, reliability and convenience;

$a_{1....6}$ = weights attached to each element of cost for conversion of all attributes to common units, typically money or time;

Then, $a_1 = 1.5$, $a_3 = a_4 = 4.5$, $a_5 = a_6 = 1.0$;

These values of weights were recommended by Crockett et al. (2004). $a_2 = 1.0$ is assumed;

Referring to the spreadsheet, In-Vehicle Time, Ti or IVT is the sum of In-Vehicle Time to the Railway Station and In-Vehicle Time from the Final Railway Station to the Final Destination. In-Vehicle Time, Ti is multiplied by 1.5 to partly calculate GTC. The value of 1.5 is recommended by Crockett et al. (2004). a_2

t_{ij}^{x} = access time to and from stations is also Access-Egress Cost (RM). Access-Egress Cost (RM) is the sum of TCStn4Survey and TCFinalDestination from the data of the O-D survey results. Access-Egress Cost data were obtained from the face-to-face interview. In the IBM SPSS spreadsheet, TCStn4Survey refers to access travel cost to the railway station where the survey was conducted whereas TCFinalDestination defines egress travel cost from the final railway station to the final destination. Wait cost at stations equals 4.5 multiply WaitTime, Tw. WaitTime, Tw was obtained from face-to-face interview based on the personal experiences of the *KTM Komuter* passengers or respondents. Similarly, interchange time equals 4.5 multiply Transfer Time, b. Fare charged to travel (RM) means *KTM Komuter* fare (ticket price). Terminal cost refers to motorcycle and car parking rates at the rail stations. Finally, there was no application of modal penalty in the current research, which means the GTC is the total of 1.5IVT, access-egress cost, 4.5WaitTime, Tw, 4.5Transfer Time, b, fare charged to travel and terminal cost. In addition to that, there was no field measurements done to specifically measure or quantify the parameters of the modal penalty like security, comfort, reliability and convenience on train and at rail stations as to these parameters were not easily quantifiable.

Result of the Calculations of the GTC is as follows:

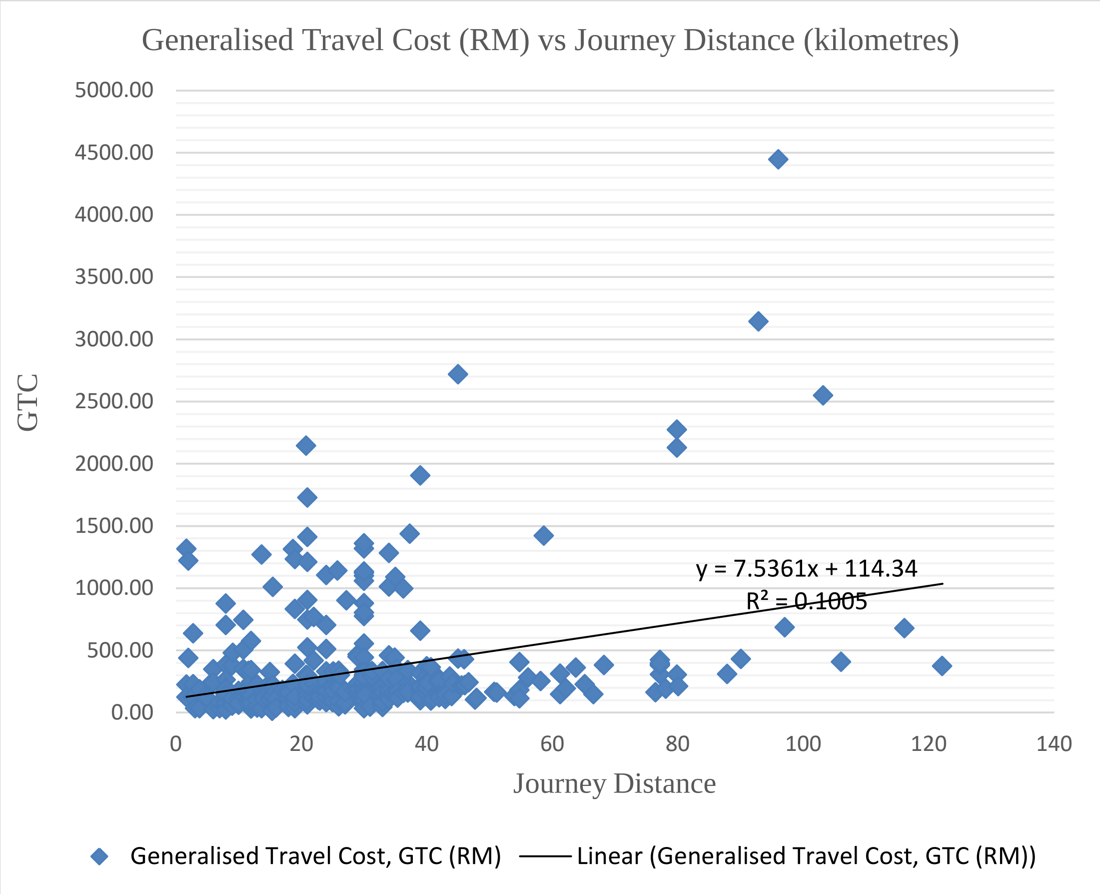


Figure 6.22 GTC in Malaysian Ringgit (MYR) vs Journey Distance (kilometres)

About three quarters of the 377 respondents had experienced GTC of lesser than RM500.00. However, this RM500.00 was still relatively high compared to the GJT made or GTC in units of time. The term GTC in units of time is also known as total weighted travel times. Roughly 25% had to bear GTC of between RM500.00 and RM4500.00, indicating higher amounts of GTC. GTC was extremely high because access-egress cost and interchange cost were extremely high too. The access-egress cost was between 0 and RM110.50 (£18.91) with mean value at RM5.62 (£0.96) and standard deviation at 9.142. The interchange cost was between 0 and RM218.00 (£37.30) with mean value of RM11.63 (£1.99) and standard deviation at 25.086. GTC was greater for male (2.65%), 20 to 29 years old (2.39%) and adults (3.18%) compared to 3 parents with small children, one disabled person, one wheelchair user, 1.33% of the users were 30 to 39 years old, 2 persons (0.53%) 50 to 64 years old and only one person (0.27%) was under 20 years old. From the sample, young (in their 30s) mothers faced greater time penalties than other parents with small children as a result of greater in-vehicle times and access-egress times. A linear trendline showed that GTC increased partly at a steady rate corresponding to the increasing journey distance, specifically over a 122.2-kilometre distance, thus supporting that *KTM Komuter* fares were charged based on journey distance. The R-squared value was 0.1005, which was quite a poor fit of the line to the data points.

From the observation of the data, there was no indication of impedance values since only a minority of the respondents had no other choices of travel.

6.6 CONCLUSIONS

The travel behavioural patterns and information of commuting on KTM Komuter is further described by the capacity, built environment and LOS of *KTM Komuter*. In reality, passengers prioritized activities in deciding travel plans. Different trip purposes depended very much on passengers' income and the economic importance of their trips. This can be described by a VoT and the significance of GTC. High VoT will result in higher cost of time elements of a trip, thus resulting in increased GTC. Work commute was the largest reported purpose with 175 trips (46.5%). Of the 175 trips, 16 users had no private vehicles, 59 users had one private vehicle whereas 100 users had two or more private vehicles.

However, 100 users had car available for their trips. 77 KTM Komuter users were from 20 to 29 years old whilst 65 KTM Komuter users were in their 30s. 117 of the work commuters were females. A majority i.e. 148 of the total commuters had between two and five people (over 15 years of age) living in the household, including the respondent. The break down indicated 55, 37, 32 and 24 users had 2, 3, 4 and 5 people in the household, respectively. 101 of the total work commuters were private staff whereas 25 of them were government staff. 161 of the total work commuters were full time staff and only 8 were part time staff. 123 of the total work commuters were adults and 39 were parents with small children. 71 of the total work commuters earned a monthly income between RM1000 (£206.01) and RM1999 (£411.81) whilst 32 KTM Komuter users earned RM2000 - RM2999 (£412.02 - £617.82), 24 earned RM3000 - RM3999 (£618.02 - £823.83) and 29 earned RM4000 (£824.04) or more. 65.3% were regular users that had taken KTM Komuter at least once a week.

More than 40.0% mode share for public transport and non-motorized transport in KL positively impacts on the present study and policy implications.

Transfer enabled users to change modes in a multimodal trip. In designing a good transfer, it should be minimized to one as it troubled users in terms of lost time, additional travel costs, uncertain travel time and longer travel distances, as well as poor reliability and exhausting journeys in the KL. An integrated fare system and feeder bus system have greatly addressed the poor functions of the existing transfer points. Park-and-ride facilities would potentially ease private vehicle users to exploit KTM Komuter in the future as these users are aware of such facilities.

The percentages of KTM Komuter users who used public transport to and from the surveyed origin and destination railway stations were found to be consistent (30%) in line with the targetted KL public transport in the Ninth Malaysia Plan. The public transport captive riders surveyed were 12.5% which coincided with 12% in the current KL public transport modal split. This was probably caused by poor conditions and shortage of public transport vehicles, and limited route (service) coverages of public transport.

Useful discussions of the impact of O-D data and the characteristics of the KTM Komuter users on the travel behavior within the system and within different market segments were conducted. The Passenger Demand Forecasting Handbook (2002) provides guidelines on the analysis of total average journey time and the total average journey cost, suggesting that both values were high representing a long travel via commuter trains. Section 6.5 discusses the results of the analysis on GJT and GTC. Discussions of GJT and GTC in terms of market segments and time penalties were also done. The concept of GJT is a procedure to forecast rail demand in PDFH. Overall, the GJT values were moderate with increasing journey distances. GTC values increased at a steady rate corresponding to increased journey distances, specifically over a 122.2 kilometres, supporting the fact that KTM Komuter fares were based on journey distance.

CHAPTER 7 : RESULT: ATTITUDINAL SURVEYS

A sample questionnaire form for Attitudinal surveys is attached in Appendix A. A detailed descriptive statistical analysis and explanation of each explanatory variable is done and the survey results are also shown in this chapter. These basic descriptive statistics were utilized to summarize both the passengers' personal characteristics such as socio-economic information in general and the passengers' perception-levels of satisfaction towards *KTM Komuter* services in particular.

7.1 INTRODUCTION

This chapter presents and reviews the results of the Attitudinal surveys. The results indicate:

a) multiple reasons for taking *KTM Komuter* as the main mode for a particular trip;

b) views and perception of the users' satisfaction levels about existing services and facilities, capacity of both train coaches and station platforms (levels of crowding), and the provision of the *KTM Komuter* system;

c) suggestions or other comments from the users that may further improve the quality of services of the existing *KTM Komuter*; and

d) a better understanding of the characteristics of the users who currently exploit the services.

Six stations were also selected for the Attitudinal surveys so as to be consistent with the O-D surveys and to be representative of the real population of *KTM Komuter* users. The six stations were KL, KLS, BN, Putra, Shah Alam and Subang Jaya. However, the surveys were also inevitably conducted at five other stations such as Jalan Kastam, Pantai Dalam, Serdang, Klang and Kampung Dato' Harun. The researcher followed the previous respondent to his or her final railway station to complete the questionnaire form. These results can be used to evaluate the current *KTM Komuter* service and operation that is available, particularly the characteristics of the users and quality of service. Service planning and train operation for adequate *KTM Komuter* line and capacity is of great importance in ensuring the efficiency of travelling using *KTM Komuter* as the main local regional mode of rail transport to workplaces, colleges, and to social and shopping locations. Such efficiency of travelling using *KTM Komuter* can be measured qualitatively by getting users to provide service-related opinions and later quantitatively by modelling the feasible parameters for both the capacity and the LOS to define overall service quality. In brief, the last task involved modelling the range of LOS variables subject to *KTM Komuter* service availability to given locations and the comfort and convenience of *KTM Komuter* service provided, which were rated by users to quantify the overall service quality (Transportation Research Board, 2003).

7.2 ATTITUDINAL SURVEYS

Currently the number of *KTM Komuter* passengers has exceeded 500,000 in a day and there is also a major increase in *KTM Komuter* capacity (supply) comprising

38 electric multiple unit (EMU) sets (six train coaches per set) known as 'MyKomuter' which arrived in 2012. The latter is a result of *KTMB*'s choice of service plan to deal with service frequency and the increase in the volume of passengers in the future (The Economic Planning Unit, 2010). MyKomuter carries an excess of 1,100 passengers each trip with better facilities such as intercoms, LCD information display, Dynamic Route Map, two Ladies' Coaches and CCTV. The Quality of Life Survey, 1998 verified that traffic congestion was a problem to more than 40% of KL residents because they could not reach their workplace on time (Kuala Lumpur City Hall, 2005c). In a car-dependent city like KL, optimal services will absolutely encourage people to switch from using their own private vehicles to utilising the *KTM Komuter* in accordance with an empirical evidence of *KTM Komuter* captive riders reported by the 2010 dataset of the Attitudinal surveys. Here 53.9% of them preferred not to drive private cars. Hsieh (2003), van Nes (2003) and Huisman et al. (2005) recommended that studies be done to gauge the relationship between the operator and the user and concluded that rail service planning was a quantitative approach in solving the interaction between demand and supply. In demand analysis, users should be short-sighted in selecting *KTM Komuter* service because their behavioural choice of train service (Nurul Habib and Zaman, 2012) will be used to develop both the train elastic demand model and choice model as highlighted by Daly et al. (2012). This train demand model will then solve service choice problem with elastic (variable) O-D demand for a regular interval or a periodic timetable. In other words, this model represents a route choice problem on a service network with a generalized cost function. Therefore, there is a need for the rail operator to enhance the quality of services with respect to capacity and LOS (Huisman et al., 2005). Travel behaviour concerns what people do over space and

how they use it while travelling (Mohd Khalis Ikhwan, 2007). Various previous studies on practical train capacity found space of train to be more than just describing the train performance (operation), travel speed, service reliability, and riding comfort or level of crowding measured by passenger loads (Transportation Research Board, 2003). Transportation planners consider LOS as the quality of service on transportation infrastructure generally linked to vehicle and railway line's time and space (Nuryantizpura, 2007, Huisman et al., 2005). Since demand varies over time and space, such service quality should be evaluated empirically over time and space too (Chien, 2005).

7.3 CHARACTERISTICS OF *KTM KOMUTER* USERS

The following basic personal particulars give more background information regarding the external factors that affect *KTM Komuter* demand. Such factors are the socioeconomic and demographic characteristics, including the type of land uses. In specific, they include the proportion of nationality, the number of students, age groups, tourists, handicapped persons, pregnant women, wheelchair-bound users and families, employment status, monthly income distribution, private vehicles ownership and so on. These attributes affect users in making travel decisions subject to perceptions (Daly et al., 2012), purposes and frequencies (Jansson, 1993), alongside the related process of mode choices (Daly et al., 2012, Nurul Habib and Zaman, 2012, The Association of Train Operating Companies, 2002). These variables would also help to generate population growth in the Greater KL (KL and its conurbations, KLC) with appropriate growth rate for the O-D base year demand matrices (Ceder, 2007, Rail - Department for Transport, 2007).

Figure 7.1 presents the age group split among the users of *KTM Komuter*. The largest group of users was between the ages of 20 and 29 years. This represented 226 users (58.2%). The second largest group was 71 (18.3%) users in the age group between 30 and 39 years. The group of elderly that represented ages of 65 or more reported only 4 (1.0%) out of 388 which was the total number of respondents. This is most likely due to their age and physical limitations and the fact that they did not like crowded places. They were observed during the inter-peak hours. In short, the respondent pool was of an average age of between 20 and 39 years, with the minimum age being below 20 years and the maximum being between 65 years old and above.

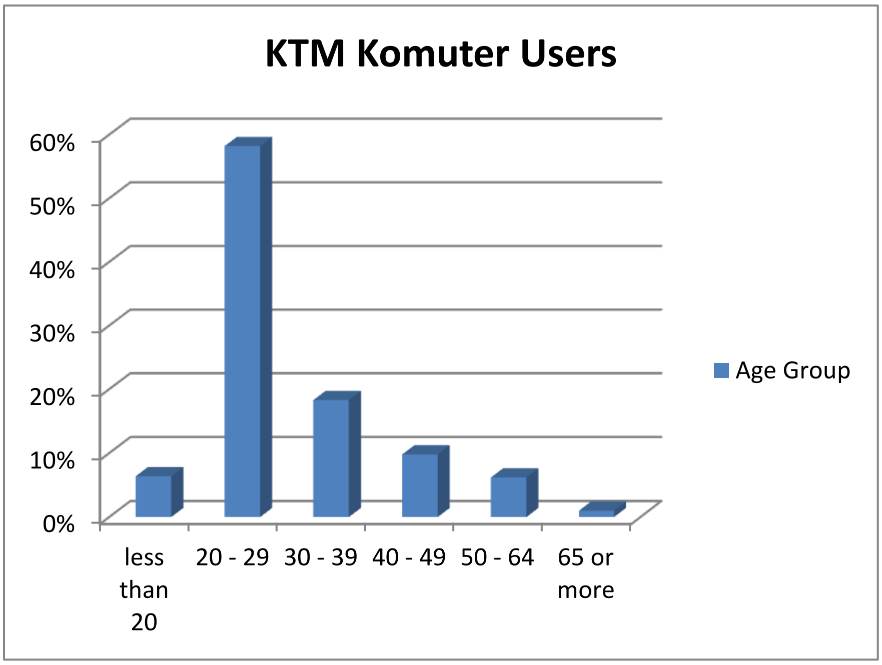


Figure 7.1 Age Group Split

Figure 7.2 shows the gender split among *KTM Komuter* users. 282 (72.7%) of the users were females whilst the remaining 27.3% were males. This result is rational when it is viewed from the extensive road safety studies done by the Malaysian Institute of Road Safety Research which found that a high number of motorcycle riders in the Klang Valley are young males, between 60% and 65% of the traffic composition. This 72.7% female *KTM Komuter* users also appear sensible for being *KTM Komuter's* captive users that have caused *KTMB* to introduce women-only coaches (in pink) in the middle of the train set (there are three train coaches per train set) since 28 April 2010. Quite recently the *Rapid KL* bus operator has also made a big difference by introducing a special bus for female bus users, suggesting that young females comprise a larger population of public transport users compared to male users.

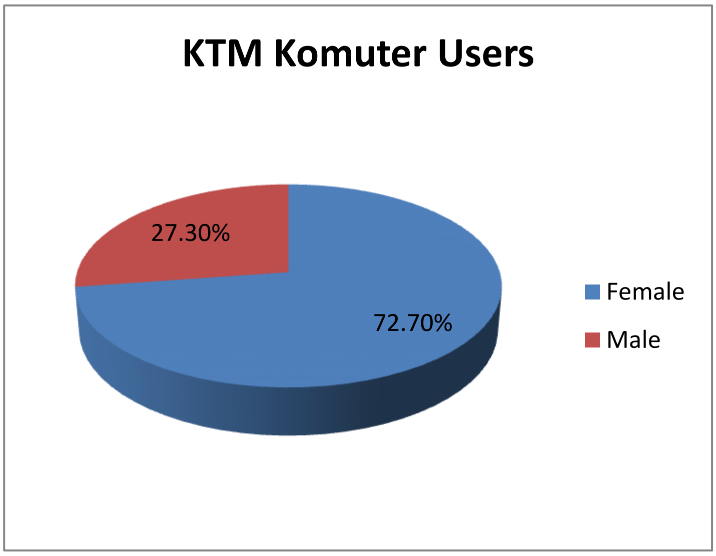


Figure 7.2 Gender Split

Figure 7.3 shows 16 (4.1%) of the *KTM Komuter* users were foreigners from Indonesia, Pakistan, Sri Lanka, Bangladesh and Madagascar.

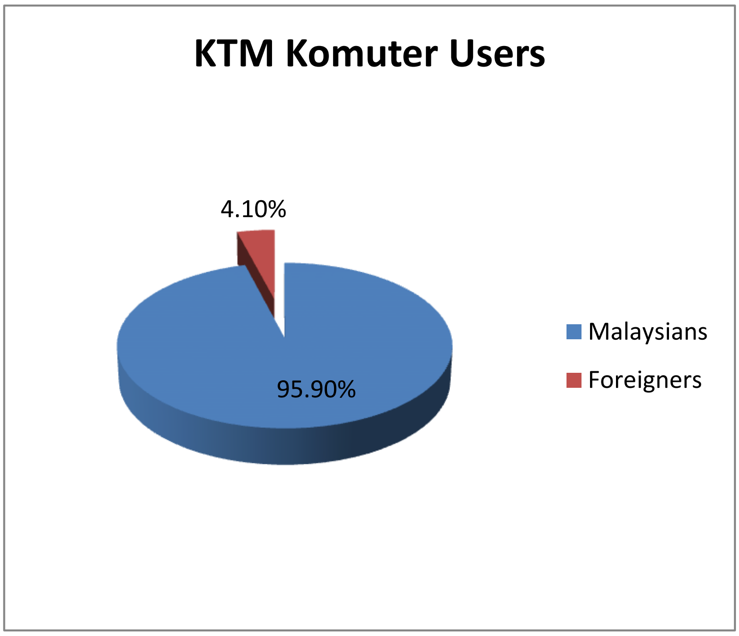


Figure 7.3 Nationality of the *KTM Komuter* users

Figure 7.4 provides information on the household size of the *KTM Komuter* users of which 76 (19.6%) from 371 (95.6%) had four persons above fifteen years of age in the household. Of the 388 valid sample, 17 (4.4%) were characterized under the group that had not given information about their nationality. Household size of two represented 74 users (19.1%) whereas 68 users (17.5%) had 5 household members.

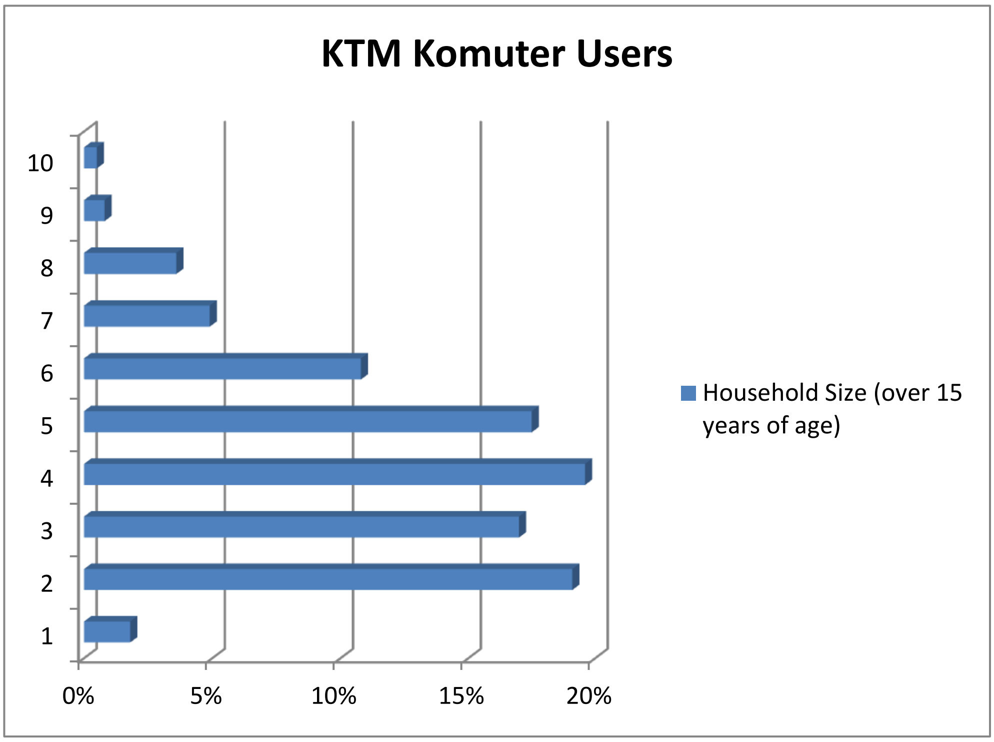


Figure 7.4 Household Size, including the respondent (user) of the KTM Komuter

Figure 7.5 shows the occupation distribution of *KTM Komuter* users. A majority of them were private sector staff. This involved 161 users (41.5%), followed by students - 127 users (32.7%) and staff from the government sector being 53 users (13.7%). This could mean workers, students and tourists do expect best services when using public transport.

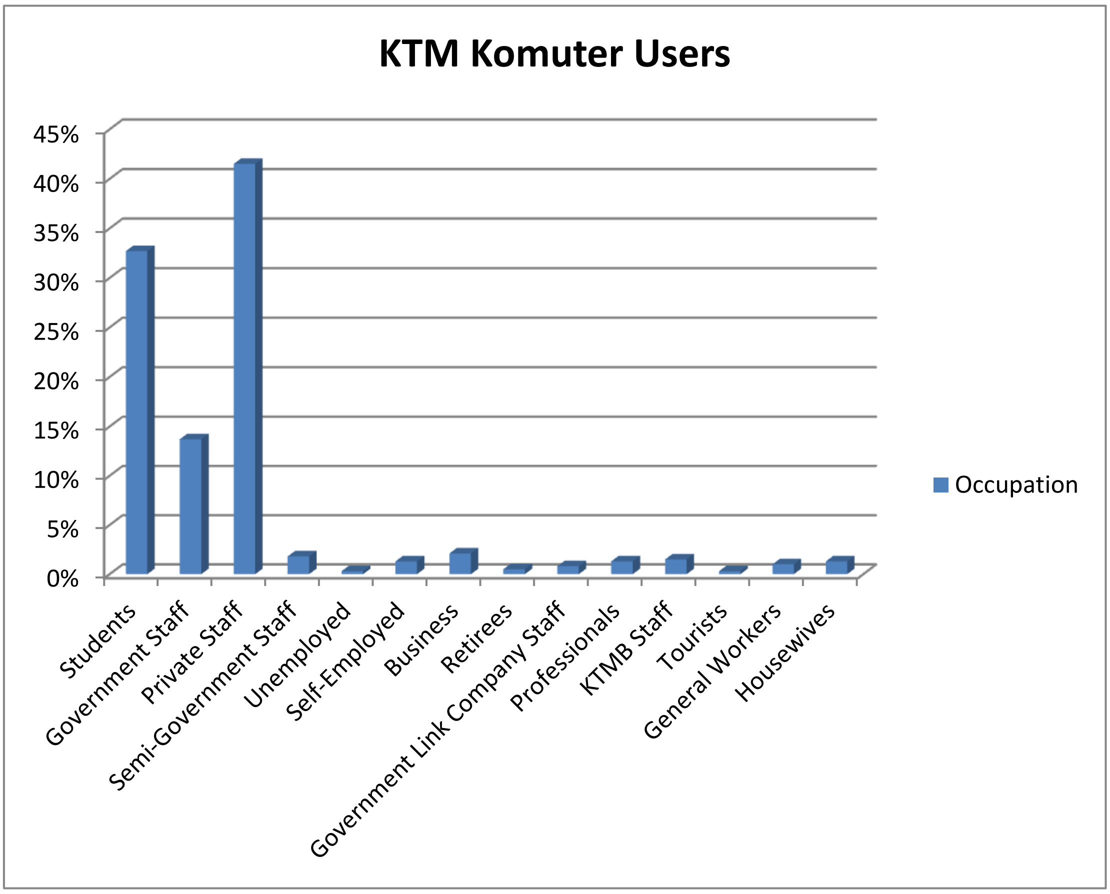


Figure 7.5 Occupation Distribution

Figure 7.6 describes that 294 (75.8%) of the *KTM Komuter* users were adults. The second category comprised parents with small children with 57 users (14.7%). 25 users (6.4%) were teenagers in the third category. Therefore, roughly one third of the adult users were students which represented the dominant group with no guardians, physical and disability restrictions.

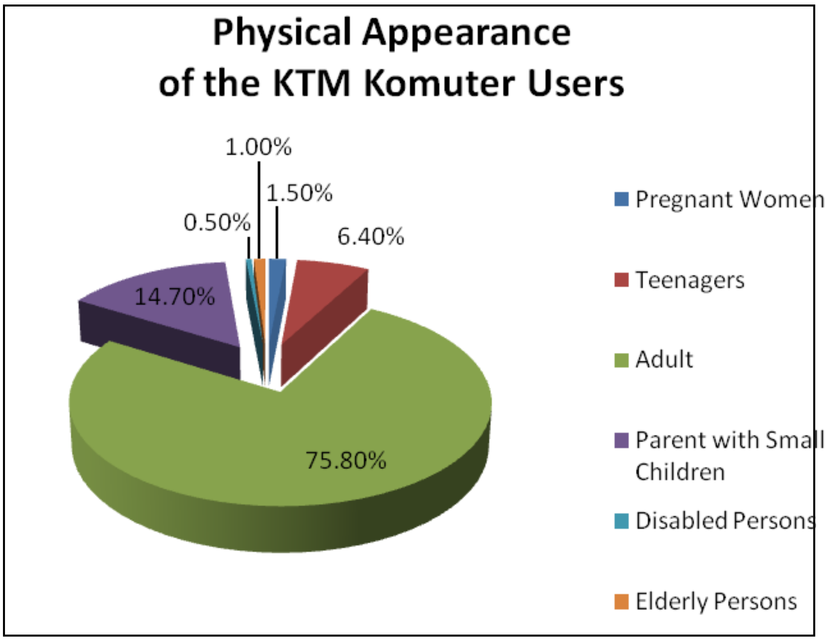


Figure 7.6 Physical Appearance of *KTM Komuter* users

Figure 7.7 depicts that 187 (48.2%) of the users earned a monthly income of less than RM2000 (£412.02). One fourth of the users (21.4%) were paid between RM2000 and RM2999 (£412.02 - £617.82) per month. 69.6% of the total users can be categorized in the medium to low income groups that were paid RM2999 (£617.82) or less per month. A fraction of *KTM Komuter* users with a salary of more than RM2999 (£617.82) per month was balanced off by a user group of 15.2% that had no specific income.

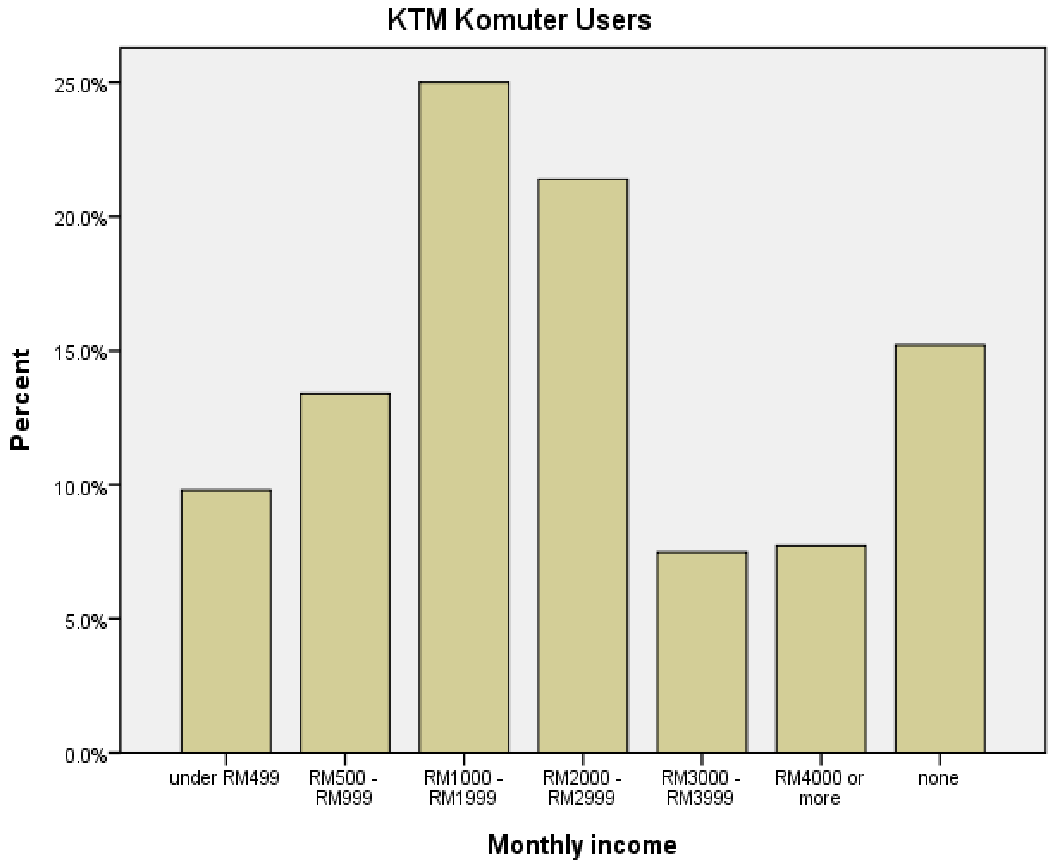


Figure 7.7 Monthly Income Distribution

7.4 REASONS FOR USING *KTM KOMUTER* AS THE MAIN MODAL CHOICE FOR A PARTICULAR TRIP

Figure 7.8 and Table 7.1 present the distribution of the main reasons to use the *KTM Komuter* as the main mode of transport for a trip. Let's code this question as 'TravelReasons'. It can be seen from both the figure and table that more than 30.0% of the users responded 'NoPrivateVeh1', which meant they had no private vehicle(s) available for the trip and therefore this reason was the first main reason among other reasons which were defined as number 1 too. The second reason most frequently forwarded was 'avoidtrfc2' with 28.6% responses, which meant they took *KTM Komuter* as the main mode of transport for a trip because they had to avoid bad traffic and this reason was the second main reason among other reasons and the possibilities number 2 which were defined as number 2. The third highest reason was 'cheaper2' (25.0%) which meant they took *KTM Komuter* as the main mode of transport for a trip because they paid cheaper fares and this variable 'cheaper' was the possibilities number 2 which were defined as number 2. And, so on from the following list of main reasons. A direct analysis using the frequency values identified the most relevant main reasons from the distribution of the main reasons in the graph (Figure 7.8) and they are arranged in descending order.

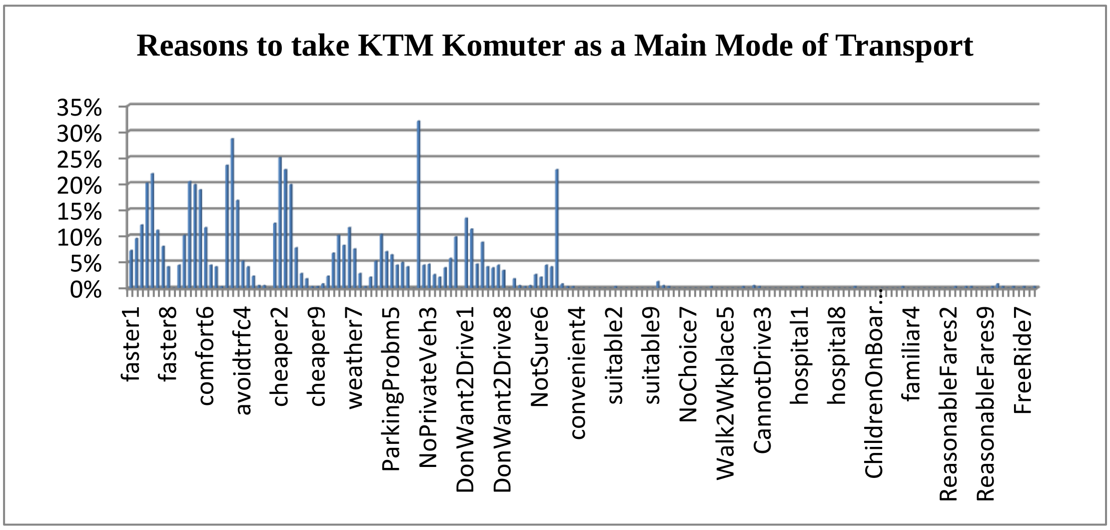


Figure 7.8 Distribution of Main Reasons to Take *KTM Komuter* for a Particular Trip

Table 7.1 Distribution of Main Reasons to Take *KTM Komuter* for a Particular Trip by Rank in terms of Percentage

The Possible Main Reasons to Take *KTM Komuter* for a Particular Trip	**Rank**
NoPrivateVeh1	32.00%
avoidtrfc2	28.60%
cheaper2	25.00%
avoidtrfc1	23.50%
cheaper3	22.70%
NotSure9	22.70%
faster5	21.90%
comfort3	20.40%
faster4	20.10%
cheaper4	19.80%
comfort4	19.80%
comfort5	18.80%
avoidtrfc3	16.80%
DonWant2Drive1	13.40%
cheaper1	12.40%
faster3	12.10%
comfort6	11.60%
weather6	11.60%
DonWant2Drive2	11.30%
faster6	11.10%
ParkingProbm3	10.30%
comfort2	10.10%
weather4	10.10%
NoPrivateVeh8	9.80%
faster2	9.50%
DonWant2Drive4	8.80%
weather5	8.20%
faster7	8.00%
cheaper5	7.70%
weather7	7.50%
faster1	7.20%
ParkingProbm4	7.00%
weather3	6.70%
ParkingProbm5	6.40%
NoPrivateVeh7	5.70%
avoidtrfc4	5.20%
ParkingProbm2	5.20%

However, question 1 was designed to probably obtain at least two reasons and nine reasons will be the most relevant to the respondents. Empirical results revealed that there were many other factors influencing the decisions made by the respondents. Such factors included the ride being convenient and suitable to a destination, having no other better options than *KTM Komuter*, being able to walk to or from other workplace, being unable to drive, travelling from hospital, wanting to bring children on board train, being unfamiliar with roads, paying reasonable fares and obtaining free rides. Nonetheless, these factors were irrelevant because of minimal effect on the mean scores and they remained important for the knowledge of both the researcher and *KTMB*. Now, it is vital to start solving this problem via a conservative approach i.e. by assuming that each respondent had to give nine reasons to take the *KTM Komuter* for a particular trip. So, each of these reasons will be have nine probabilities. The next step is to compute the mean scores for each main reason using the analysis of descriptive statistics in the Predictive Analytics Software (PASW) Statistics. Each mean score alone cannot lead to the solution of the nature of the question i.e. ordinal (rank) scales (Foster, 1998). Each mean score will be multiplied with each number assigned to each main reason. Each main reason will be computed for its value of ranking score by simply adding all of the nine resultant mean scores. In ascending order here means the main reasons selected should be arranged from the strongest (or the most important reason) to the weakest (or the least important). In view of that, the most important reason will be denoted as number one whereas the least important reason will be coded as number nine on the list. The final ranked nine main reasons are recognized from the existing list by carefully checking the ranking values assuming that the most important reason is expected to have the lowest score while the least important reason has the highest score. The list of nine main reasons from the most important to the least important is shown below together with their ranking scores computed.

Results

The nine main reasons from the most important to the least important are

1. not wanting to drive (1.83)
2. parking poses a problem (1.96)
3. avoiding bad traffic (2.00)
4. having no private vehicle(s) available (2.23)
5. enduring weather conditions (2.58)
6. paying cheaper fares (2.84)
7. having no specific reason or not being sure (3.02)
8. experiencing a comfortable and convenient service (3.94)
9. travelling faster (4.07)

The above results are driven into the analysis of the specific proportion of *KTM Komuter* riders that do not have private vehicle(s), do not want to drive and even cannot drive at all. Figure 7.9 indicates the number of so-called *KTM Komuter* captive riders at the surveyed locations.

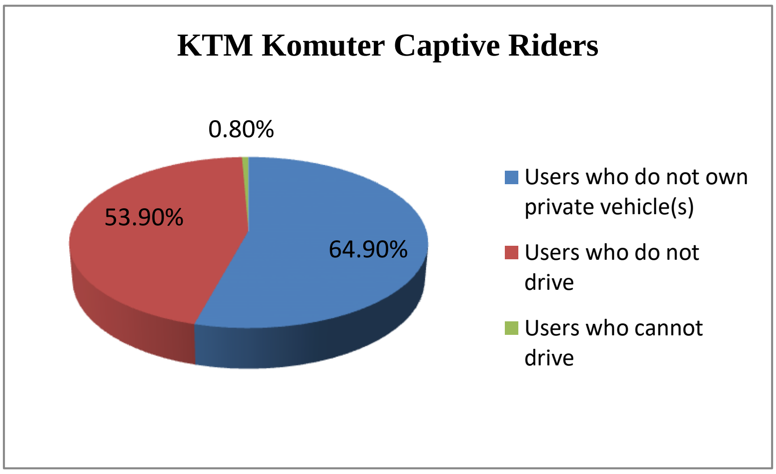


Figure 7.9 *KTM Komuter* captive riders

7.5 USERS' SATISFACTION ON THE OVERALL SERVICES, FACILITIES AND *KTM KOMUTER* PROVISION

In providing for the optimal rail service and provision, a prerequisite would be to frequently obtain feedback from the users with respect to their satisfaction levels on the current capacity and LOS offered by *KTM Komuter*.

Figure 7.10 shows the users' satisfaction levels on the current fare. 244 (62.9 %) of the users were of the opinion that the current fare system was from good to very good. About one third of them rated the fare structure as fair. The average user satisfaction score for fares was 3.79 with its standard deviation being 0.833 of which this was the highest user satisfaction score.

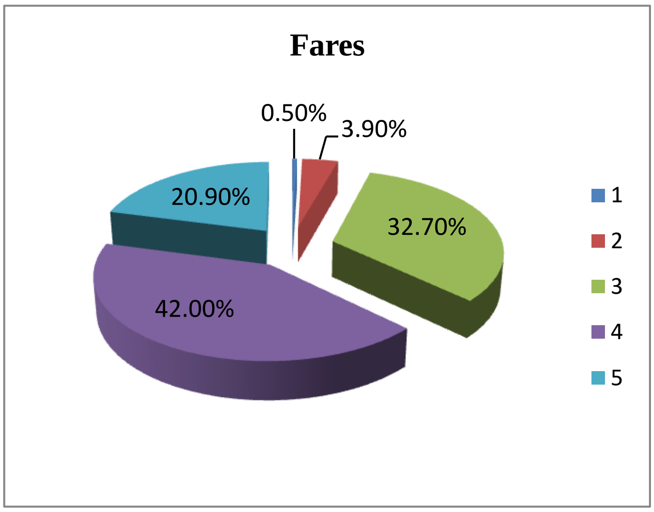


Figure 7.10 Users' Satisfaction Levels on the Current Fares

With regards to service provision, users' dissatisfaction was mainly on the special public amenities available for family, babies and handicapped persons as presented in Figure 7.11. Briefly, this provision of *KTM Komuter* services was poorly rated in comparison to the related information that reported that about 20% of KL population were highly dissatisfied with the provision of various public services and bus services were amongst them (Kuala Lumpur City Hall, 2005c). The respective user groups were 344 (88.7%), 310 (79.9%), and 291 (75.0%). The descriptive statistics information provided knowledge about the characteristics of the sample subject to satisfaction score (Pallant, 2010). Therefore, the corresponding user satisfaction scores for feeder bus services, parent(s) and small children facilities, handicapped group facilities and baby-changing facilities were calculated in terms of mean and standard deviation i.e. 1.99 (0.728), 1.70 (0.684), 2.10 (0.686) and 1.87 (0.729), respectively.

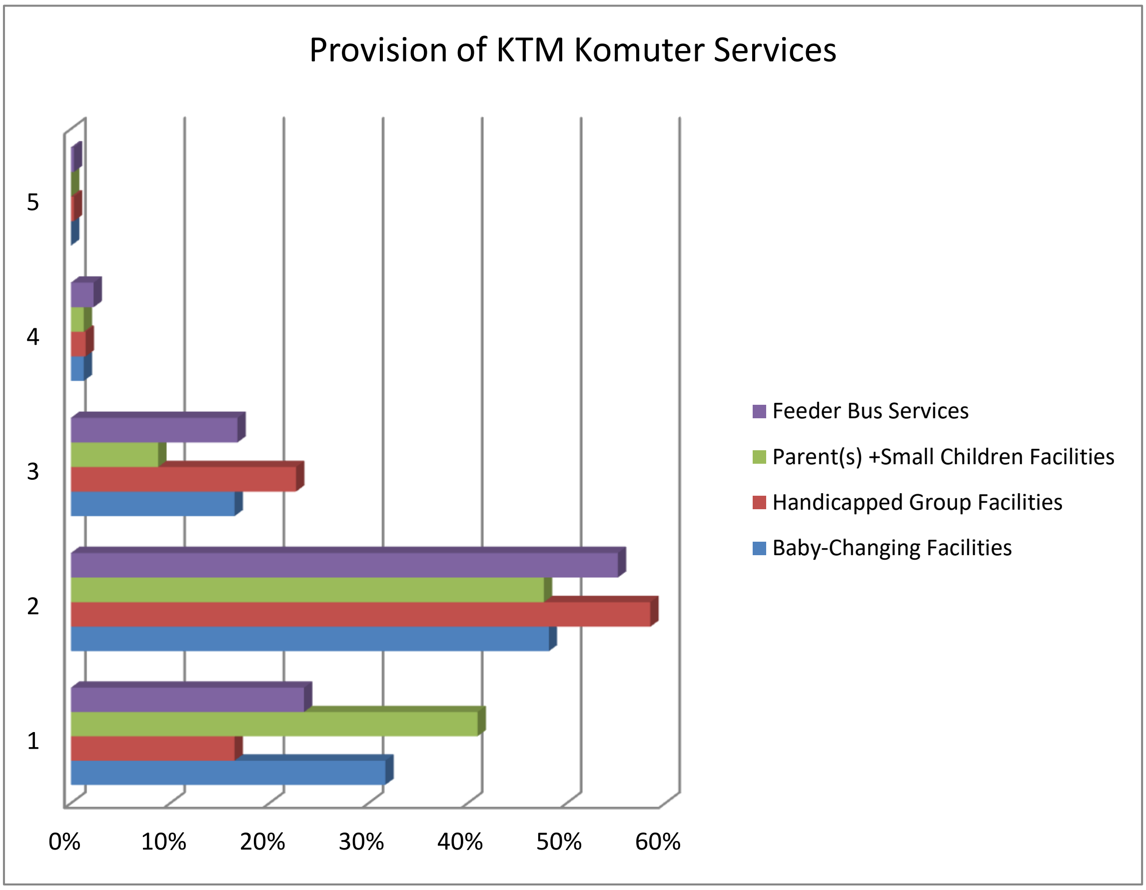
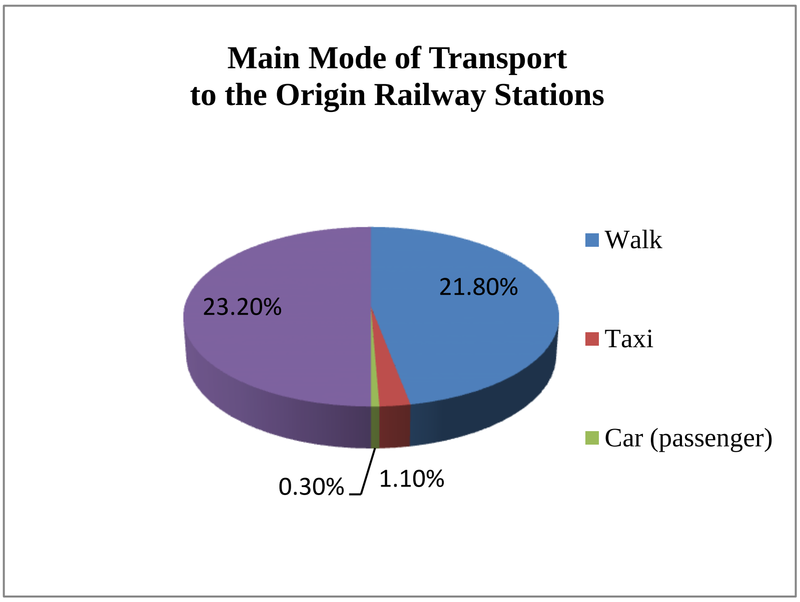


Figure 7.11 Users' Satisfaction Rate on the Provision of *KTM Komuter* Services

A high proportion of users; 305 (78.7%) also made a positive comment for feeder bus services as a result of poor to very poor such service at present. Figure 7.12 illustrates the smallest proportion of relative total purely unimodal transports, such as, walking, taking a taxi, and using a car (passenger), which would shift to bus feeder as a main mode of travel to and/or from the nearest railway stations. The percentages did not sum up to 100 because the summation of unimodal transports on the right hand side of the half of the pie chart was equal to the total purely unimodal transports on the left hand side of the other half of the pie chart. Figures 7.13 and 7.14 were also in the same setting as the pie chart in Figure 7.12. A lack of feeder bus services to and from *KTM Komuter* stations had caused inadequate passenger catchment areas of *KTM Komuter* and its coverage, indicating low quality accessibility (Syahriah et al., 2013).

Figure 7.13 summarizes the percentages of non-motorized transport and the simplest motorized transport or multimodal transport like walking, riding a bicycle, taking a taxi or a car, using the motorcycle, and bus. These users were expected to use the feeder bus service every day if there was good bus feeder supply and condition, along with an acceptable route service coverage. *KTMB* should provide some facilities to make *KTM Komuter* stations more accessible, such as building walking paths to the stations, providing bicycle parking bays and taxi stands instead of providing feeder services and 'park and ride' facilities similar to those of The Land Transport Authority of Singapore (LTA). Likewise, Figure 7.14 estimates that 88.0% of the users at the station of origin and 97.6% of the users at the destination stations would be potential users of feeder buses because the rates of bus and taxi fares were very expensive. High petrol prices was also a deterrent factor that made 164 (42.3%) users request that the *KTM Komuter* operator, *KTMB* made improvements based on suggestions and complaints made to the stations on a regular basis.



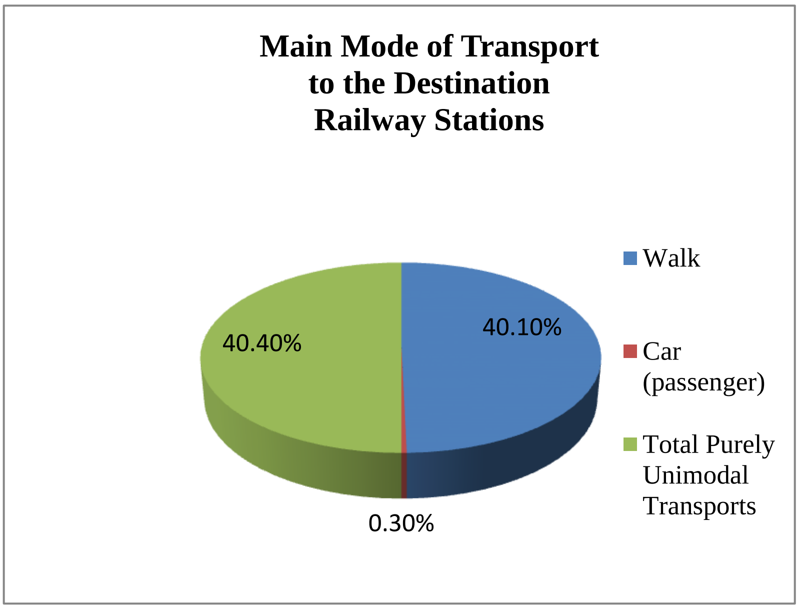
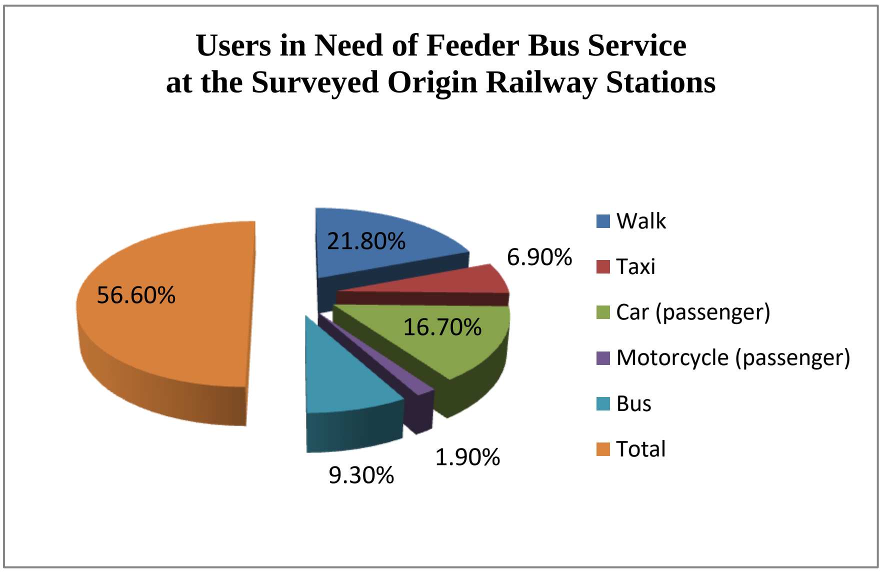


Figure 7.12 Potential Feeder Bus Users at both the Railway Stations of Origin and the Destination Railway Stations



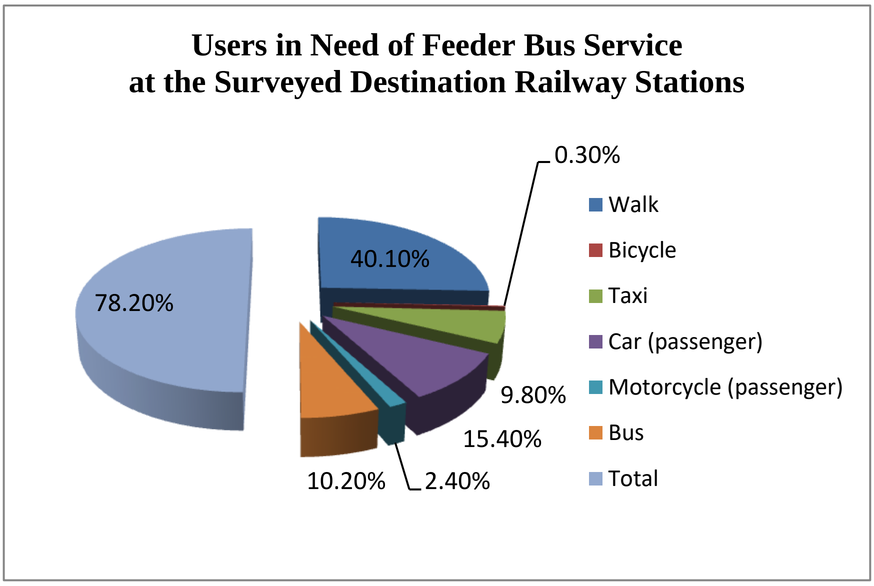
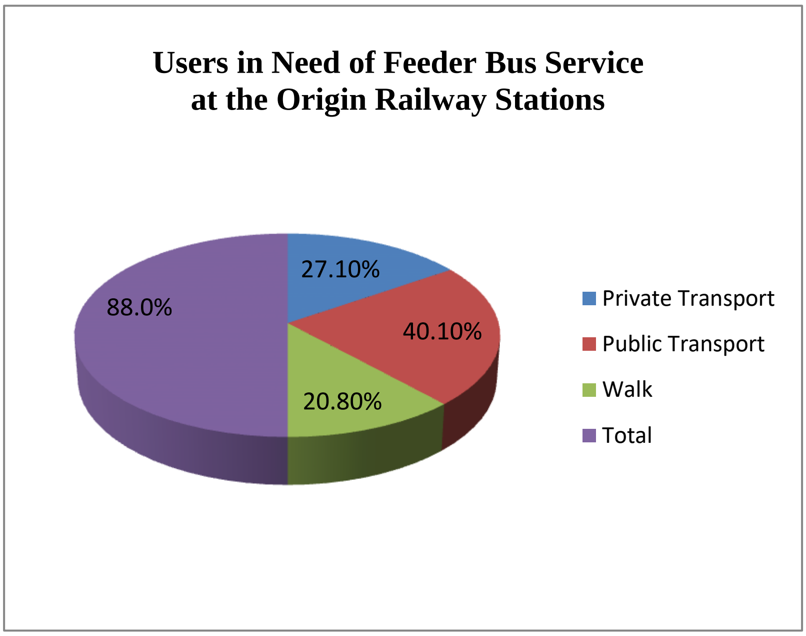


Figure 7.13 Potential Feeder Bus Users at both the Railway Stations of Origin and the Destination Railway Stations



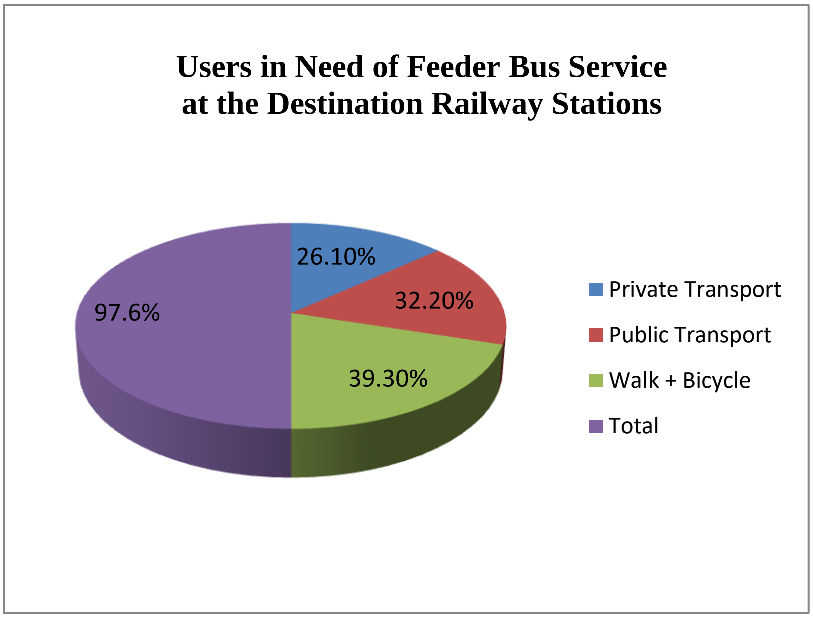


Figure 7.14 Feeder Bus Demand Forecast at both the Railway Stations of Origin and the Destination Railway Stations from different perspectives

Attitudinal survey analyses the distribution of user satisfaction levels on attributes of travel time-related services incorporating frequency, schedules and reliability/punctuality. The respective satisfaction scores for these attributes were 2.42, 2.34 and 2.23. According to this analysis, there is relatively little variance observed amongst the attributes. Most of the users responded that they were dissatisfied with the travel time on the *KTM Komuter*. The lowest average level of user satisfaction level score could be observed in reliability/punctuality which indicated 2.23. This was close to 2.00 for poor level.

In terms of services and facilities, nearly 55.0% of respondents were highly dissatisfied with the total travel times of the trains as shown in Figure 7.16 of which poor service frequency, unexpected long waiting times (Larsen and Sunde, 2008, Huang and Niu, 2012, Gallo et al., 2011) and unreliability/dispunctuality had caused them to suffer serious overcrowding (Chan, 2007, Chun et al., 2011, Takagi et al., 2006) during peak hours (van Oort and van Nes, 2010; Hirsch and Thompson, 2011) and 224 (57.8%) of them were dissatisfied with the timetable (schedule). Based on research finding, Chan (2007) added that platform wait time (another term for passenger wait time) was most negatively impacted by crowding. Moreover, the long waiting times were often aggravated by the effects of time pressure (Strombeck and Wakefield, 2008) of regular train cancellations and delays due to some trains being under maintenance and some of them encountering breakdowns (Figure 7.15) (Khan and Zhou, 2010). When these unreliable services also happened due to *KTM Komuter's* train capacity constraints, most of the trains operated with large headways between 30 minutes and two hours regardless of the time variation, meaning such poor service frequencies reflected the serious waiting times earlier mentioned and more stress was inflicted on the passengers, particularly in the process of interchanging journeys (Wardman et al., 2001); in turn this reflected the inconvenience of the current schedule for passengers (Douglas and Karpouzis, 2009). However, the common lateness observed were 30, 45 and 60 minutes which were found to be consistent with the findings of Syahriah et al.'s (2008) research. This was often made worse by bad weather conditions (Alwadood et al., 2012). The route's level of discomfort defined the unreliability at operational stage (Tahmasseby et al., 2007).

Equally, the poor users experienced discomfort. They experienced weariness and annoyance (Yang *et al.*, 2010). They faced expected unacceptable waiting time (Larrain and Muñoz, 2008) for quite long with no promises and apologies from *KTMB* in advance of train cancellations and delays, thereby causing them to feel uncertain (Wardman et al., 2001) about the disorganised operations (van Oort and van Nes, 2010; Alwadood et al., 2012) and later having to exploit to alternative modes of transport like buses and the LRT systems only after the taxing episodes (Goverde, 2005). *KTMB* also took hours just to find replacement trains (Strombeck and Wakefield, 2008) without informing both the increasing stranded and waiting users at the platforms and on-board trains properly. Such unexpected long passenger waiting times occurred as a consequence of the resulting average journey times of the *KTM Komuter*. Dwell times and unplanned stops greatly impacted passengers too (Takagi et al., 2006; Huang and Niu, 2012; Frost et al., 2012; (Alwadood et al., 2012). According to one of Chan's (2007) conclusions, high excess journey times usually exhibits a high level of unreliability. Meanwhile, more and more users were boarding and alighting at the station platforms and on the trains because of a great campaign to encourage the use of *KTM Komuter* and there was also no proper pre-trip information facility within the services at all.

Pre-trip information's content in the form of message(s) could help passengers decide on how, when and where to plan and execute their travels (Hull, 2005; Grotenhuis et al., 2007). Therefore, both the short and narrow platforms and train coaches (inclusive of the train sets) were reaching almost near and or total overcapacity thus resulting in overcrowding at spaces near doors (Frost et al., 2012). These overcrowding phenomena were also noticeable in many empirical rail studies conducted by Nuryantizpura (2007), Harmize (2008), Mohd Khalis Ikhwan (2007), Takagi et al. (2006), Nor Diana (2012). Huisman et al. (2005), Nor Diana (2012) and Frost et al. (2012) also explained regarding an inefficient rolling stock circulation that would usually take place on a long railway line as a result of variations in passenger demand and train supply on the rail network.

Figure 7.15 Passengers' Overcrowding and The Long Waiting Times at the Kg. Dato' Harun's Station Platform. Passengers Were Aggravated by The Effects of EMU 05 Encountered Breakdown for KL Inbound direction

Almost 60.0% of the users were unhappy with the current *KTM Komuter's* reliability/punctuality as a result of the above mentioned congested platforms and trains to a large extent (Lam et al., 1999, Chun et al., 2011). Turning to passengers' dissatisfaction with the timetable (i.e. almost accounting for 58.0% of the responses), one possible explanation for this finding was that the planned timetable was extremely unreliable as a result of the above-mentioned irregular *KTM Komuter* operations; There was a substantial lack of timetable stability (Frost et al., 2012) which in turn, led to poor QOS (Toš et al., 2011) and lower LOS (van Oort and van Nes, 2010).

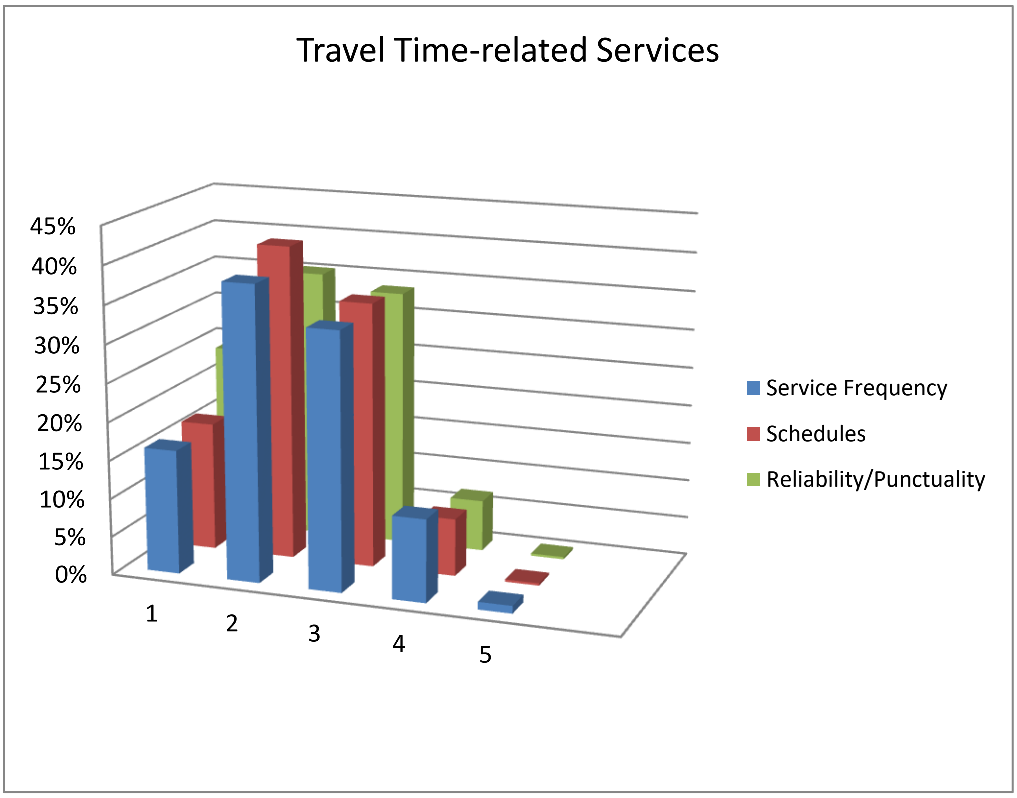


Figure 7.16 Rating Results for the Line's Timetable Journey-related Services

Figure 7.17 shows 167 (43.0%) of the commuters faced problems finding seats and this was justified by the satisfaction score of 2.64 (0.928), especially in train coaches during peak periods. About a similar number of users, 178 (45.9%) also found the current standing space very limited or inadequate for standees (Figure 7.18). The narrow size of the coaches was intended to cope well with the varied levels of crowding. Thus, its satisfaction rate was at 2.60 (0.937). Observations reveal that the train coaches were easily overcrowded before-and-after working hours and even during lunch times, night shifts, weekends and national holidays. The increasing boarding and alighting passengers that arrived/alighted at the stations and the carried passengers on trains at random forced a large number of them to stand for a long time and a long distance of travelling. This phenomenon was observed elsewhere, for example by Goverde (2005), Larsen and Sunde (2008), Denke (2003). This situation made the passengers feel uncomfortable and dissatisfied, especially after a long hectic day of working. Nuryantizpura (2007) also found similar results. For this reason, the users and the general public knew that it was the right time for *KTMB* to provide more train coaches so that longer train sets would operate on tracks at a high service frequency.

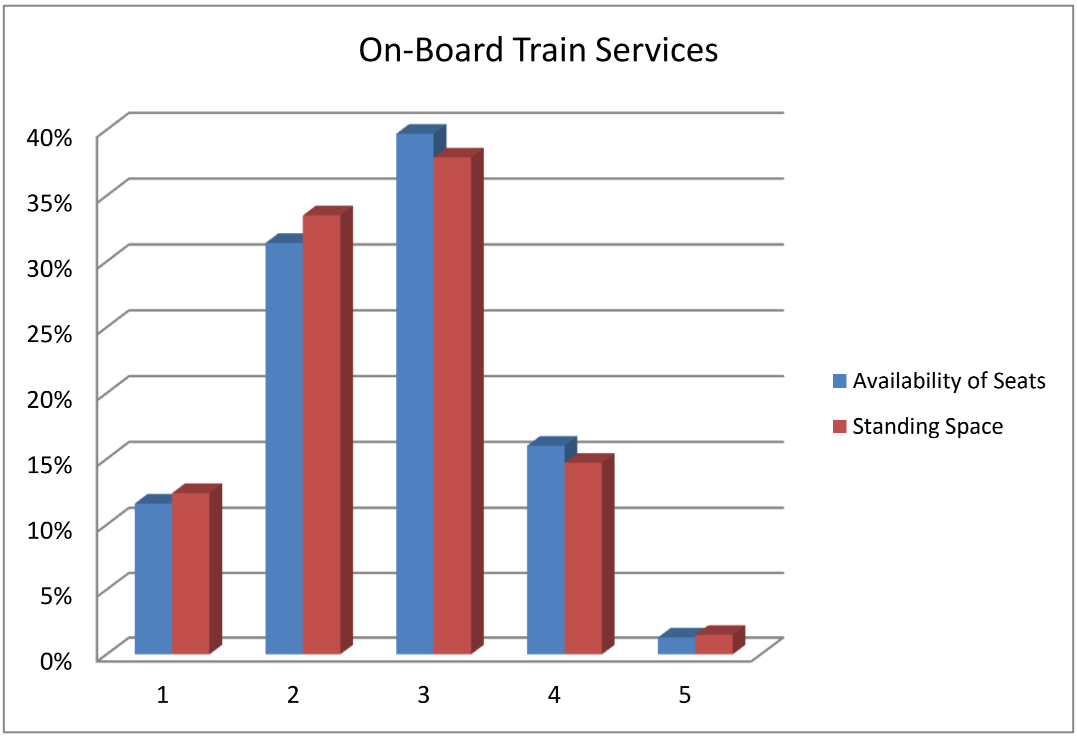


Figure 7.17 Users' Satisfaction Rate on the Current Train Coaches Capacity or Level of Crowding

Figure 7.18 Typical Level of Crowding OnBoard *KTM Komuter* Train Coach Interior

Other components of services and facilities that desired regular maintenance were safety and security features of the train coaches like the interior comfort, air-conditioning system, seat conditions and supply of litter bins, shops availability at the railway stations as well as private vehicle user's such as car (driver)-, car (passenger)- and car (driver, shared)-based facilities (Figure 7.19). The satisfaction rates for these facilities stood at 2.95 for parking lots, 2.90 for park-and-ride capacity and 2.81 for kiss-and-ride size confirmed thus indicating users were rated such facilities fairly. Figure 7.20 shows that car sharing resulted in park-and-share so that a total of about 4.0% ride-sharing the *KTM Komuter* for the trip indicated very low private motorized vehicles occupancy among *KTM Komuter* users. This is common in KL which was evidenced by related results from Roadside Interview (O-D) surveys in 2007. Such surveys resulted in the single passenger occupancy rate being 49.4% of the total sample whereas 31.7% represented road transport occupancy with two passengers.

In addition, the average car occupancy rate was 1.80 while motorcycle had an average occupancy of 1.00 (Ministry of Works, 2009). The number of car (drivers) and motorcycle (drivers) in rail stations showed an indication of the usage of park-and-ride facilities and all the car owners (drivers) were those that actually desired quality park-and-ride facilities at rail stations (Figure 7.20). The number of car and motorcycle passengers indicated the usage of kiss-and-ride facilities (Figure 7.20). These services and facilities had levels of dissatisfaction between 19.3% and 34.0%. More users' dissatisfaction that was, from 19.5% to 38.7% was specifically owing to the provision of passenger information such as route time clock and signage and notice board, and station provision. Unfamiliar riders will easily feel confused if the signages and notice boards did not function well (Agarwal, 2008). Railway station provision includes acceptable quality and quantity of station lightings, safety equipment, toilets, shower and prayer rooms, overhead bridge, telephones, auto teller machines (ATMs) and ticket vending machines (TVMs), and turnstile.

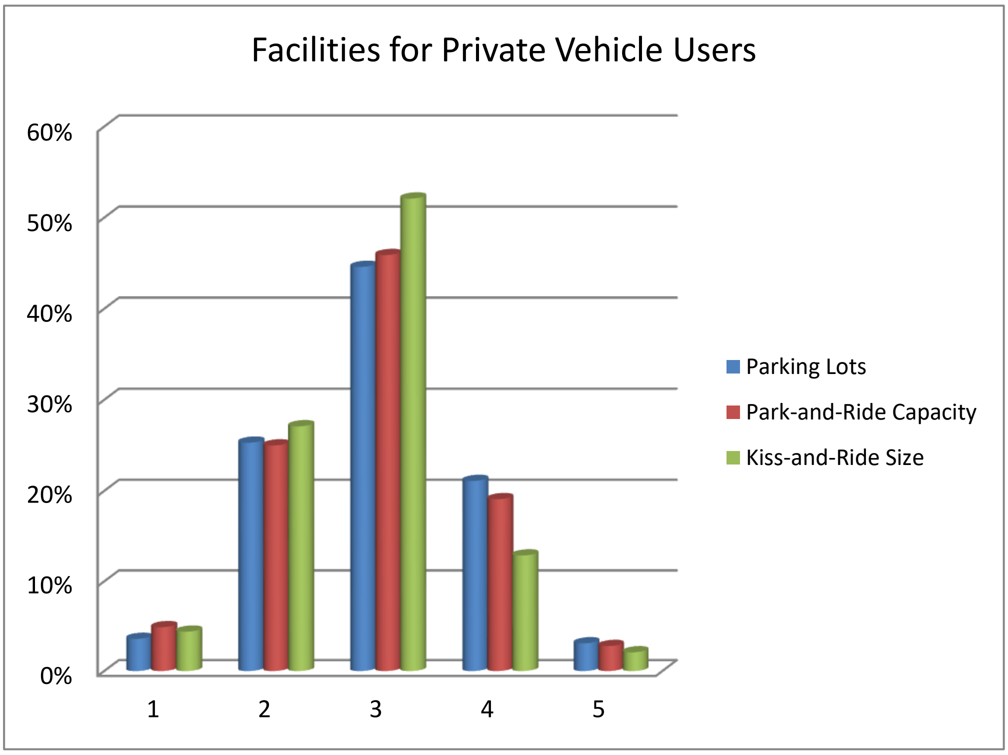
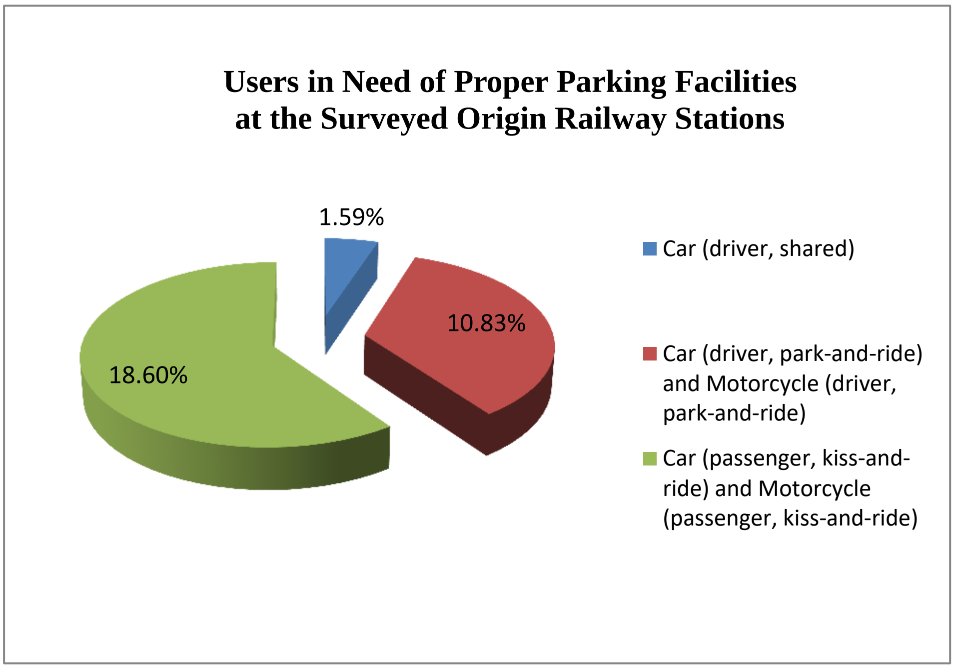


Figure 7.19 Users' Satisfaction Rate on the Current Parking Services and Facilities



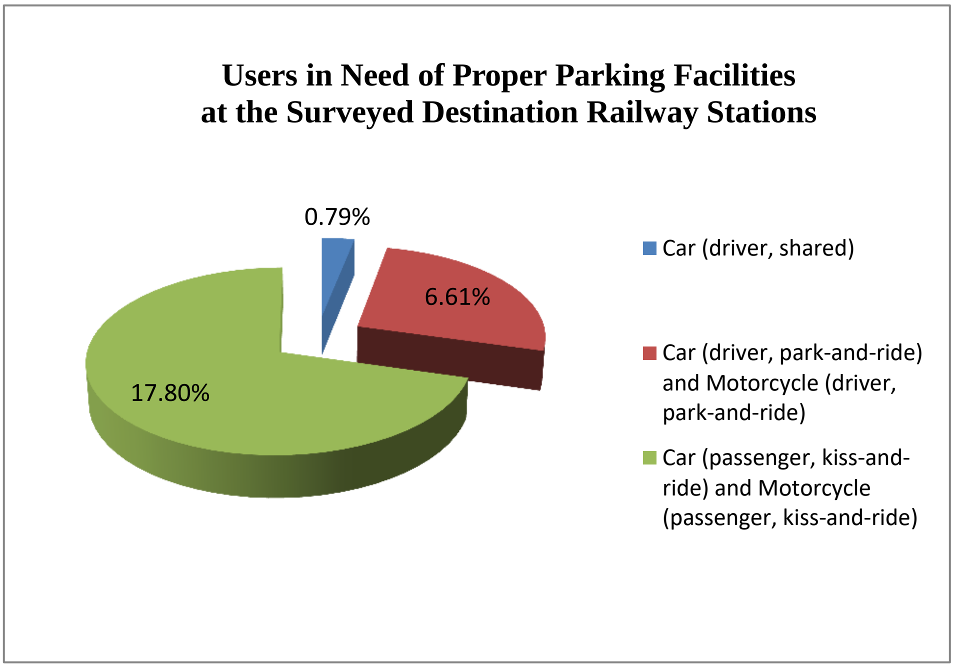


Figure 7.20 Users in Need of Proper Parking Services and Facilities at both the Railway Stations of Origin and the Destination Railway Stations

In Figure 7.21, the results of the observations reveal that only a small proportion of the users i.e., 57 (14.7%) was satisfied with the LOS, thereby noting that 80 (20.6%) of the *KTM Komuter* users rated the overall service quality to be from poor to very poor whilst the remaining 281 (72.4%) rated the overall service quality as fair. The absence of local specification on the rail capacity and LOS, (Transportation Research Board, 2003) guided the current headway of 15 minutes to 20 minutes for peak hours in servicing LOS C while a headway of 30 minutes and above was observed during inter-peaks and off-peaks marked LOS E. This means the overall service quality of the *KTM Komuter* is still acceptable at 87.1% (Figure 7.22) with reference to the result of descriptive statistics for the mean being 2.84 whereas LOS's meant 2.97. Figure 7.22 also summarizes the satisfaction rates at 3.21, 3.06, 3.20, 3.44 and 3.32 for features of riding quality, riding comfort, convenience, staff courtesy and customer services. Therefore, the *KTM Komuter* system performance and the LOS need improvement. Higher performance would require increased travel speed, reliability/punctuality, and capacity with additional train coaches (Vuchic, 2007, Transportation Research Board, 2003, Leong, 2010).

Ceder (2007) described LOS improvements covering various aspects from adjusted route size, schedule, service frequency, daily service hours, reliability, travel speed, basic infrastructure, safety and security. According to Vuchic (2007), nearly 30.0% rated riding quality and riding comfort to be good although almost 15.0% responded both seat availability and standing space to be of good quality (see Figure 7.17), 84.0% stated that they were fairly satisfied with the current convenience of using the *KTM Komuter* even though they had used a high number of transferring modes, and approximately 41.0% and 46.0% of the users were very satisfied with *KTMB*'s *service from the heart* (sincere and warm) – hospitality service with respect to customer service and staff courtesy, respectively. Service from the heart and satisfactory routes (see Figure 7.16) reflect the unique image and identity of *KTM Komuter*. Service from the heart and satisfactory routes were also termed as the greatest pull factors among *KTM Komuter* users. 82.5% of the 388 respondents rated transfer facilities to be fair to very good.

Rail service quality can be classified into non-timetable and timetable journey related attributes, performance variables, access and egress characteristics, facilities for private vehicle users, modal integration facilities, and provision of passenger information and ticketing system; journey time, frequency and interchange. These were amongst the key attributes of timetable journey (The Association of Train Operating Companies, 2002). In that sense, services emerged in various attributes in a real-world of rail infrastructure (Tahmasseby et al., 2007). Ceder (2007) viewed service quality as positively influencing public transport demand when there were significant changes made to service coverage, service frequency and fare reduction. The other optimal strategy was to measure the relation between the main attributes like frequency, generalized journey time, and fares for service quality changes in forecasting rail travel demand (Jansson, 1993, Wardman, 1994). Moreover, this overall service quality variable was also tested for its relationship with a variety of variables in Question 1 so as to measure the implications of users' the main reasons for utilising the *KTM Komuter*. The results are illustrated in the graphical presentation as shown in Figure 7.23. It can be seen that the O S Q was mostly rated at a mean of nearly 3.0.

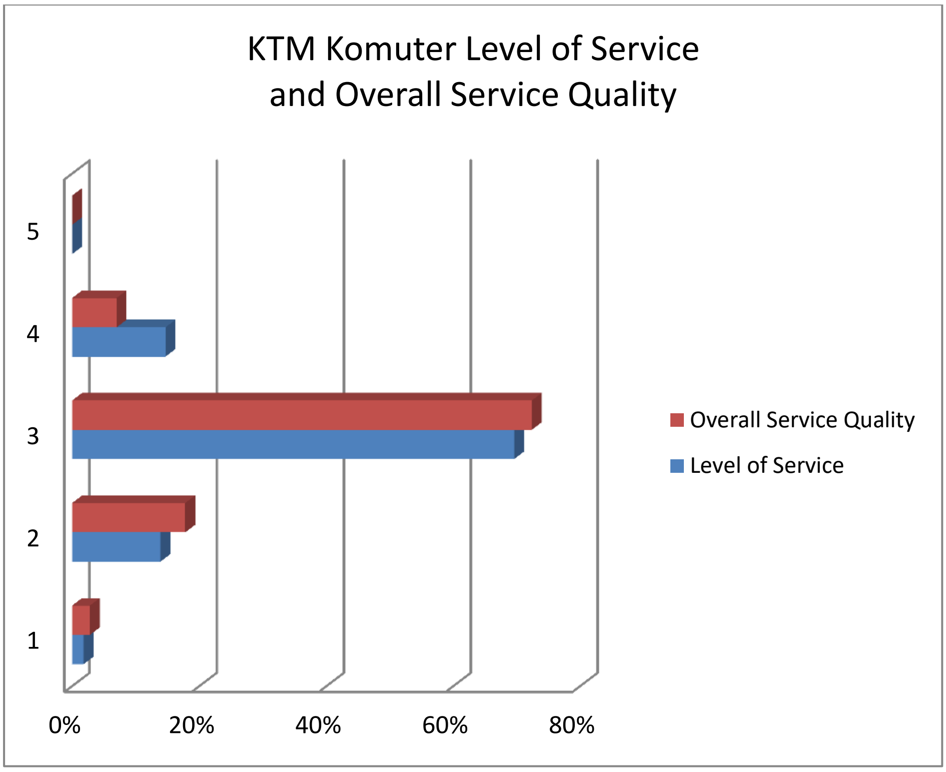


Figure 7.21 Users' Satisfaction towards the Current LOS and OSQ

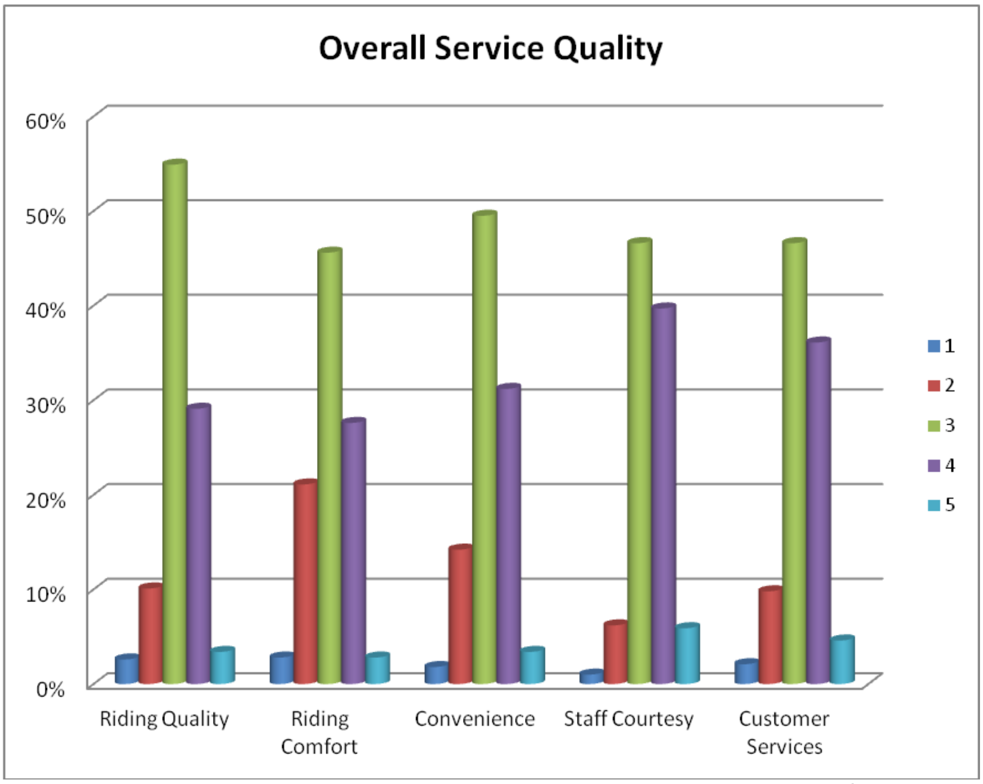


Figure 7.22 Users' Satisfaction towards the Major Components of the OSQ

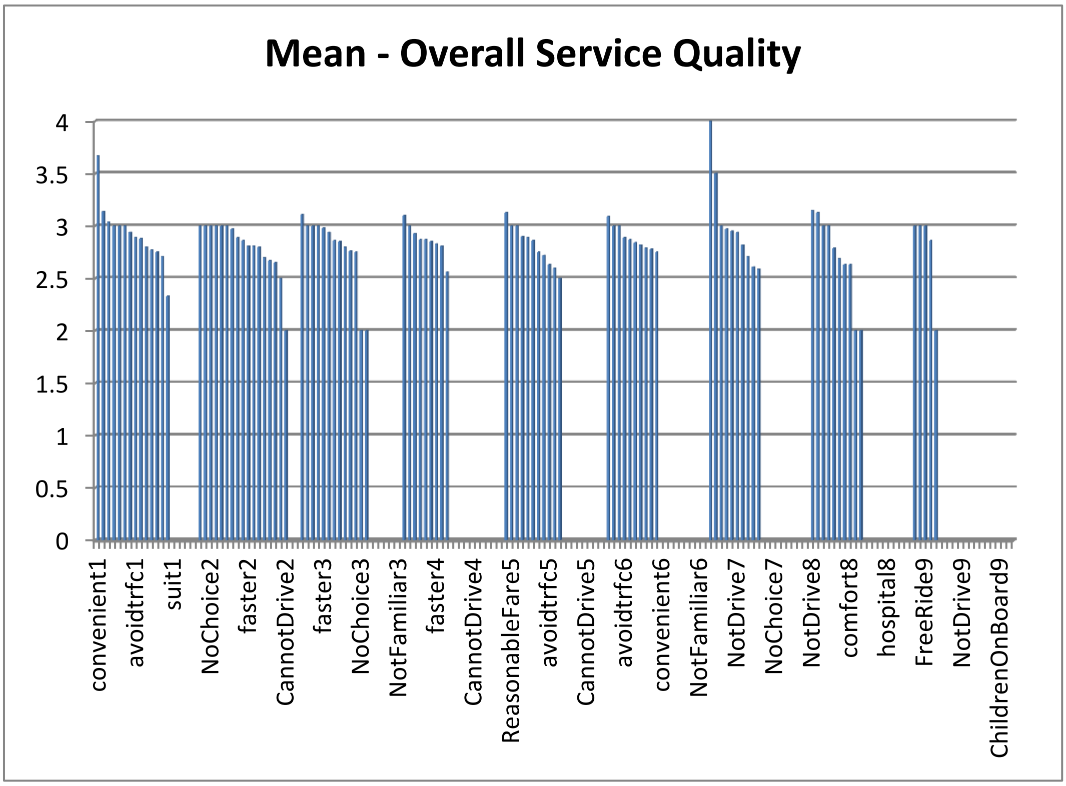


Figure 7.23 Users' Satisfaction Rates on the OSQ

User characteristics did impact on user satisfaction. In other words, user satisfaction varies by user group. For example, adult female commuters were feeling more satisfied than disabled male commuters and adult female commuters were feeling more satisfied than female leisure travellers accompanied by children.

7.6 USERS' SUGGESTIONS AND OTHER COMMENTS

Interestingly, a majority of the *KTM Komuter* passengers participated in the interview-questionnaire surveys very well by spending time and in helping to make recommendations and by providing comments to many relevant aspects. It can be concluded that they used the *KTM Komuter* service on a regular or daily basis. This was amongst the key attributes of timetable journey. Figure 7.24 lists the suggestions and comments from 243 (62.6%) users, which may further improve the travel time and quality of services of *KTM Komuter*. Improved *KTM Komuter* service quality had close ties to timetable and non-timetable journey related attributes and performance variables included service frequency (28.6%), comfort and convenience (24.2%), schedules (19.3%), reliability/punctuality (12.6%), quality of stations, platforms and train coaches (4.4%) and safety and security (3.6%). 37.4% of the passengers did not provide feedback to this open-ended question.

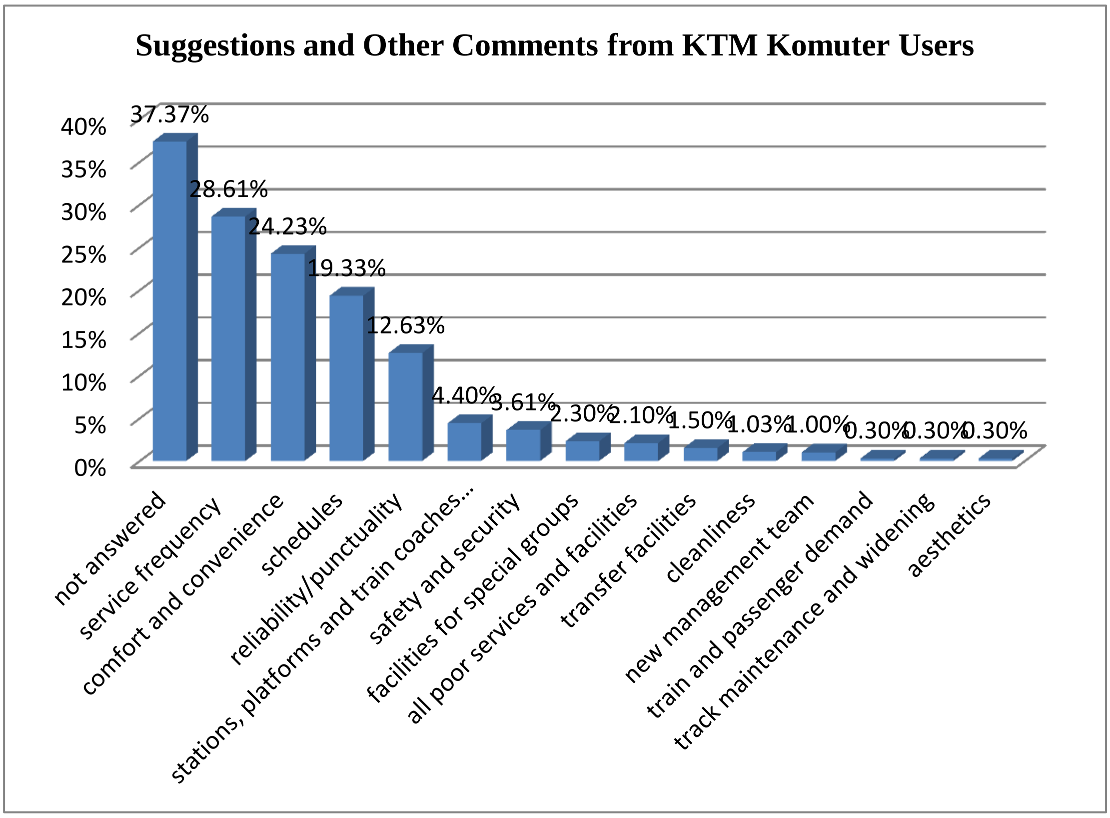


Figure 7.24 Suggestions and Other Comments from *KTM Komuter* Users

7.7 CONCLUSIONS

The foremost result concluded that users were highly satisfied with the fare levels because they knew that the current LOS of the *KTM Komuter* was still fair and thus they were not willing to pay additional fare rates. They also perceived that *KTM Komuter* was being operated by the semi-government sector, the oldest national public regional commuter rail service (Mohammad, 1989) and that it was the only inter-city transit (stage) train in the urban region compared to other rail systems. The prime concern was to improve feeder services and public amenities like ‘family’ facilities and baby-changing facilities. With regards to satisfying the need for comfort, convenience and safety of the users, this is the right time for

KTMB to design an appropriate timetable-related and on-board train services, and to look into station facilities, load factor/efficiency, easy usage, transfer/interchange facilities, crowding level, general comfort level (for instance, cleanliness, seats) and vehicle age on the basis of Macário's (2010) work for the TOOLQIT case studies at the European level. There has been longer average waiting time due to longer average running time. There was also low quality of trains, inadequate capacity and under-design of railway track capacity. These confirm the problem statements under Section 1.2. Therefore, KTMB needs to redesign the system running speed by speed fleeting the train paths. In addition, enhanced capacity and efficient management of railway track capacity are also required.

There were high percentages of KTM Komuter captive riders 54.7% mentioned that they did not want to drive and cannot drive at all. This supports the problem statement under Section 1.2 i.e. rail is often deemed as a promising mode of transport to reduce high dependency on cars. So, it is the responsibility of KTMB to significantly provide maximum comfort, convenience and safety to passengers. The problem statement of poor level of security and safety is not valid because it is not measured explicitly in this study.

This study shows that people who take the *KTM Komuter* will definitely have better perception of its operations and services if services are improved. This perception was noted when the surveyors approached the target users. The respondents welcomed the surveyors for the interviews and they who responded positively and rationally to the questions because of their natural interest towards the subject (Coolican, 2009). Surveyors should simplify the questions to a spontaneous conversation to make the interview interesting. As a consequence, both the surveyors and the users would feel comfortable during the interviews. These users can generate positive communication (feedback), thereby influencing other users' perceptions of certain travels in a positive manner (Adibah, 2007). According to Strombeck and Wakefield (2008), users in a positive mood tend to contribute to more favourable product evaluations than those in a negative mood. However, some users may not necessarily display a negative emotional state, but they can be expected to be more analytical and critical to rate core service functions. Being able to gauge the users' perception and satisfaction levels means it is not impossible to influence and even predict their future behavioural intentions. This will aid very much in future decision-making processes (Gärling and Axhausen, 2003) regarding travel destinations. The above Stated Importance method based on Attitudinal surveys is subjected to a shortcoming of inaccurate responses and answers (de Oña et al., 2012). This is due to the heterogeneity of the passengers' perception of services. The qualitative nature of certain aspects, the different passengers' attitudes and ways of viewing services, and the social and economic characteristics of passengers and their preferences describe the term heterogeneity. The above mentioned statements prove that there is a need to analyze how both users and potential users perceive the entire rail-feeder bus services as stated in the problem statements under Section 1.2.

The results clearly indicated that users and potential users experienced problems with the system in terms of travel times, overcrowding, pre-trip information, reliability and punctuality. These impacted the perceptions of OSQ by turning the perceptions of OSQ to slightly negative causing KTM Komuter passengers and potential KTM Komuter passengers to rate the OSQ fair. Therefore, KTM Komuter users' and potential KTM Komuter users' satisfaction were low.

Since service quality data is in the quantitative form, the summarised results of mean satisfaction scores and standard deviations are shown in Table 7.2. Service quality data can be distributed, for example, in the median, if this data is classified as qualitative and specifically classified as ordinal. Qualitative data involves non-numerical data. The results of the Attitudinal surveys identified the various aspects of the current services, facilities and provision of *KTM Komuter* that can be primarily improved in relation to its quality so as to attract both private car and motorcycle users. At the same time, from the planning and operation view point, *KTMB* can diversify both the train supply and passenger demand by creatively establishing a potential *KTM Komuter* route network or route choice (trip availability) and accessibility. A practical service frequency, reliability/punctuality and schedules of the newly *KTM Komuter* train sets which arrived in 2012 can also be of great help.

Table 7.2 Mean Satisfaction Scores and Standard Deviations

Continuous Variables	Mean	Std. Deviation
Riding quality on the train	3.21	0.767
Station/stop quality	3.36	0.826
Convenience	3.20	0.788
Transfer facilities	3.29	0.852
Service frequency	2.42	0.921
Schedules	2.34	0.851
Reliability or punctuality	2.23	0.903
Safety and security	3.12	0.902
Aesthetics	3.03	0.735
Environmental friendliness	3.12	0.785
Comfort of train coach interior	3.06	0.844
Air-conditioning of train coaches	3.05	0.955
Cleanliness of train coaches	3.37	0.826
Seat	3.14	0.822
Litter bins	2.82	0.941
Fully covered platforms	3.46	0.842
Cleanliness of platforms and stations	3.51	0.779
Staff courtesy	3.44	0.744
Customer services	3.32	0.796
Fares	3.79	0.833
Number of retail outlets	2.93	1.020
Parking lots	2.95	0.865
Park-and-ride capacity	2.90	0.871
Kiss-and-ride size	2.81	0.795
Availability of seats	2.64	0.928
Standing space	2.60	0.937
Station lightings	3.11	0.783
Safety equipment	3.02	0.804
Toilets, shower and prayer rooms	2.78	0.862
Baby-changing facilities	1.87	0.729
Overhead bridge	3.01	0.746
Facilities for handicapped groups	2.10	0.686
Facilities for parent(s) plus small children	1.70	0.684
Telephones	2.81	0.832
Route time clock	2.89	0.841
Signage and notice board	3.17	0.837
Suggestion & complaint management systems	2.61	0.803
Feeder bus services	1.99	0.728
Auto teller machines	2.72	1.027
Turnstile	2.98	0.710
Ticket counters	3.18	0.791
Ticket vending machines	2.94	0.893
Electronic ticketing system	3.23	0.821
LOS	2.97	0.599
Overall service quality	2.84	0.578

KTMB's first approach of the planning of routing provision had been to extend its services to the Pelabuhan Kelang – Sentul route to Batu Caves for a distance of 7 kilometres with three other new stations namely Batu Kentonmen, Kampung Batu and Taman Wahyu. Such new stations formed the Batu Caves – Sentul line effective from 29 July 2010. Another pro-active measure to effectively communicate with users is to provide information of train cancellations and delays in advance and to minimize delays by improving the route time clock (digital message signs) that is to synchronize the route time clock from one station to another. The conclusion reached was that the Attitudinal surveys studied the behaviour of passengers towards *KTM Komuter* services and the results of the surveys were very useful and could be very helpful not only for passengers but also for the rail operator(s) involved.

CHAPTER 8 : RESULT: ATTITUDINAL MODELS

8.1 INTRODUCTION

The history of factor analysis begins in 1904 relating to psychology. It relates to statistical theory and statistical applications. Factor analysis is a handy tool of a multivariate statistical method for investigating interrelationships among variables for complex concepts such as QOS and SQ attributes, psychological attributes (i.e. personality, intelligence, happiness, depression, etc.), customer satisfaction, air pollution, diet, socioeconomic status, etc. It is an exploratory tool for researchers. It is also called a tool for data reduction. It investigates concepts that are not easily measured directly by reducing a large number of variables into fewer, underlying interpretable factors. Factors are a set of variables represented by a smaller number of variables. Factors are formed and are normally relatively independent of one another. There are several methods of factor analysis. However, factor analysis with principal components analysis (PCA) is the most commonly applied. Factor analysis is totally dependent on correlations between variables. It differs from regression in that it does not have a dependent variable. The goal in factor analysis is to identify factors that explain the interrelationships among the original variable.

The theories of SEM were formed in Bock in 1960. Over the past two decades SEM has been a useful and popular tool in Behavioural Sciences because of four advantages. These advantages are:

i) SEM enables the integrative study of complex patterns of relationships among the constructs in a conceptual model;

ii) The measurement of unobserved variables can be modelled explicitly and the effect of measurement error on structural relationships can be considered;

iii) It allows flexibility; and

iv) It enables latent variable modelling.

SEM is a general statistical modelling technique. It generally enables multivariate data analysis. Statistically, it extends the ANOVA and multiple regression analysis. An approach of SEM is based on a model system. SEM is the combination of measurement model and regression or path analysis (structure) or path model. The measurement model is evaluated through CFA. CFA tests theoretical relationships between variables when a factor structure is known. As a guide, CFA is used first if there is a known structure in the questionnaire. A key feature of SEM is that the latent constructs can only be inferred from the observed measured variables. These latent constructs cannot be directly measured.

8.2 STATISTICAL ANALYSIS

Analytical procedures were conducted using the statistical packages of IBM SPSS and SEM-AMOS. This section comprises the exploratory data analysis.

8.2.1 Reliability Analysis

Reliability is the degree to which a scale/instrument consistently measures whatever it measures. Croncbach’s Alpha coefficient is a measure of the internal consistency of a series of scale items (Drea and Hanna, 2000). Its value is between 0 and 1. If Croncbach's Alpha value exceeds 0.60, the scale is said to have internal consistency, hence being reliable. The lower acceptable bound for alpha value is 0.70 (Nunnally, 1978) as cited by (Lai and Wu, 2011, Pallant, 2010); however, values above 0.80 are preferable. The reliability of the 45 items of *KTM Komuter* Service Quality Attributes is analyzed through the Croncbach's Alpha value at 0.938, which exceeds the requirement for a basic research. This 0.938 is higher than 0.60, meaning the 45 scale questions are consistent and thus reliable for measuring satisfaction levels of the customers. 0.938 also suggested a very good internal consistency reliability for the scale with this sample. In addition to that, the test was 93.8% reliable and it was 6.2% unreliable. The Cronbach's Alpha figures (i.e., specifically, Cronbach's Alpha if Item Deleted) of these 45 items ranged from 0.936 to 0.939 suggesting that the item represented reliable measures for each of the dimensions. High Cronbach's Alpha values for each dimension support that the items are reliable in measuring the underlying concepts.

8.2.2 Factor Analysis

The passengers were asked to rate the 45 variables on a five-point scale according to their experience. The test of validity of data was examined with the help of a Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and the Bartlett's test of sphericity. The KMO measure of sampling adequacy and the Bartlett's test of sphericity are two statistical measures generated by IBM SPSS to help assess the factorability of the data (Pallant, 2010; Pronello and Camusso, 2011). Bartlett's test of sphericity is a statistical test for the overall significance of all correlations within a correlation matrix (Hair et al., 2006). Bartlett's measure tests the null hypothesis that the original correlation matrix is an identity matrix (Field, 2005). Thus, these two tests satisfied the validity of data for factor analysis. The structure in factor analysis complemented the structure of the measurement instrument with the Kaiser-Meyer-Olkin Measure of Sampling Adequacy value (or reliability value) of 0.903 exceeding the recommended acceptable value of 0.60 and the Bartlett's test of sphericity value of 0.000 reaching statistical significance ($p<0.05$). The two statistical measures generated indicated great support for the performance of factor analysis.

The collected data were statistically analyzed in order to ensure that the objectives of the research were achieved. Data collected from field surveys were processed to conduct an approach of sequential factor estimation known as factor analysis. Data screening or cleaning process was performed by replacing the missing values that were denoted by '99' with mean values. The exploratory Factor Analysis (EFA) is then deployed for data reduction and summarization to acquire key factors or components that the respondents are concerned with. Through EFA, the service quality attributes which determine the satisfaction of *KTM Komuter* service was extracted the following way.

Table 8.1 Total Variance Explained Resulted from Factor Analysis

Components Of Rail Service Quality Attributes	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.384	27.521	27.521	12.384	27.521	27.521	4.676	10.390	10.390
2	3.106	6.902	34.423	3.106	6.902	34.423	3.468	7.706	18.097
3	2.029	4.509	38.933	2.029	4.509	38.933	3.317	7.372	25.468
4	1.857	4.127	43.059	1.857	4.127	43.059	3.001	6.669	32.138
5	1.688	3.752	46.811	1.688	3.752	46.811	2.450	5.445	37.583
6	1.446	3.214	50.025	1.446	3.214	50.025	2.392	5.316	42.899
7	1.348	2.995	53.020	1.348	2.995	53.020	2.371	5.269	48.168
8	1.291	2.869	55.889	1.291	2.869	55.889	1.988	4.418	52.586
9	1.202	2.671	58.561	1.202	2.671	58.561	1.910	4.245	56.831
10	1.076	2.390	60.951	1.076	2.390	60.951	1.854	4.120	60.951

A scan down of the values are provided in the first set of columns, labelled Initial Eigenvalues in Table 8.1. Eigenvalue is termed column sum of squared loadings for a factor and it shows the amount of variance of the observed variables accounted for by a factor (Hair et al., 2006; Muhamad Nazri et al., 2014). The eigenvalues for each component are listed. Only ten components recorded eigenvalues above 1 (12.384, 3.106, 2.029, 1.857, 1.688, 1.446, 1.348, 1.291, 1.202 and 1.076), meaning these ten factors were retained. Any factor with an eigenvalue ≥ 1 explains more variance than a single observed variable. Hence, these ten factors were significant. Other components of rail service quality attributes with eigenvalues below 1 were rejected from the list of factors (Chua, 2009). These ten components were the solutions explained unidimensionally a total of 61.0 percent of the variance (see Cumulative % column). The total variable explained suggested that it extracted ten factors which accounted for approximately 61.0 percent of the variance of the relationship between variables. So, a factor analysis of the scale 45 variables from the Attitudinal Surveys indicated the presence of ten broad factors.

Table 8.2 provides information of how much of the variance in each item was explained. "Low values (for example, less than 0.30) could indicate that the item does not fit well with the other items in its component" (Pallant, 2010). "Large communalities indicate that a large number of variance has been accounted for by the factor solution. The proportion of variance on any one of the original variables, which is captured by the extracted factor is known as communality" (Bharathi, 2010). Table 8.2 also depicts that after ten factors were extracted by the method of Principal Component Analysis and the rest were retained, the communality was 0.464 for variable 1, 0.596 for variable 2, 0.451 for variable 3, and so on. It can be concluded that 46.4 percent of the variance of variable 1 was accepted by the ten extracted factors together. Each value under column extraction showed a percentage of similar response by the passengers against each attribute. The value for park-and-ride capacity attribute showed that 81.8% passengers had a similar response over this attribute. Meanwhile, it was 79.8% for reliability or punctuality, 79.3% for parking lots and so forth for the others. All the loadings in Table 8.2 were positive. "A negative loading indicates that this variable has an inverse relationship with the rest of the functions. However, anything above 0.44 could be considered salient with increased loading becoming more vital determining the factor" (Bharathi, 2010).

Table 8.2 Communalities

Number	***KTM Komuter* Service Quality Attributes**	**Initial**	**Extraction**
1.	Riding quality on the train	1.000	0.464
2.	Station/stop quality	1.000	0.596
3.	Convenience	1.000	0.451
4.	Transfer facilities (stair-climbing, escalator, cross-platform transfers)	1.000	0.651
5.	Service frequency	1.000	0.719
6.	Schedules	1.000	0.763
7.	Reliability or punctuality	1.000	0.798
8.	Safety and security	1.000	0.546
9	Aesthetics	1.000	0.554
10.	Environmental friendliness	1.000	0.550
11.	Comfort of train coach interior	1.000	0.650
12.	Air-conditioning in train coaches	1.000	0.597
13.	Cleanliness of train coaches	1.000	0.666
14.	Seat	1.000	0.621
15.	Litter bins	1.000	0.538
16.	Fully covered platforms	1.000	0.584
17.	Cleanliness of platforms and stations	1.000	0.635

Table 8.2 continued

18.	Staff courtesy	1.000	0.713
19.	Customer services	1.000	0.742
20.	Fares	1.000	0.546
21.	Number of retail outlets	1.000	0.578
22.	Parking lots	1.000	0.793
23.	Park-and-ride capacity	1.000	0.818
24.	Kiss-and-ride size	1.000	0.710
25.	Availability of seats	1.000	0.769
26.	Standing space	1.000	0.768
27.	Station lightings	1.000	0.647
28.	Safety equipment	1.000	0.530
29.	Toilets, showers and prayer rooms	1.000	0.396
30.	Baby-changing facilities	1.000	0.620
31.	Overhead bridge	1.000	0.670
32.	Facilities for handicapped groups	1.000	0.545
33.	Parent(s) including small children facilities	1.000	0.575
34.	Telephones	1.000	0.505
35.	Passenger information: route time clock	1.000	0.502
36.	Passenger information: signages and notice boards	1.000	0.567
37.	Suggestions & complaints management systems	1.000	0.522
38.	Feeder bus services	1.000	0.468
39.	Auto Teller Machines (ATMs)	1.000	0.494
40.	Turnstile	1.000	0.507
41.	Ticket counters	1.000	0.648
42.	Ticket Vending Machines (TVMs)	1.000	0.589
43.	Electronic ticketing system: smart card, Touch n Go (TnG), etc.	1.000	0.553
44.	LOS	1.000	0.628
45.	Overall service quality	1.000	0.635

Rotation methods are either orthogonal or oblique. Data was analyzed using principal component extraction with an orthogonal (varimax) rotation method by simply assuming that the factors in the analysis were *uncorrelated* (Brown, 2009, Pronello and Camusso, 2011). Moreover, "even the issue of whether factors are correlated or not may not make much difference in the exploratory stages of an analysis. A method of orthogonal rotation is much simpler to understand and interprete because each variable loaded heavily onto a single factor – that is to say it is easier to identify variables that measure each factor and minimize the overlap across factors." (Brown, 2009, Popuri et al., 2011). To put it another way, no specific rules have been established to guide researchers in selecting a particular orthogonal rotational technique (Hair et al., 2006). In this research, the varimax orthogonal rotation method was chosen because the variables (factors) were a set of uncorrelated measures for subsequent use in other multivariate techniques (Muhamad Nazri et al., 2014). Instead, varimax is easily the most commonly used rotation (Homem de Almeida Correia et al., 2013) to analyse construct dimensionalities (Muhamad Nazri et al., 2014) and it is often recommended by many statisticians and researchers as a default option in addition to its ability to be the rotation of choice for many applications. "The goal of varimax rotation is to minimize complexity of factors (simplify factors) by maximizing the sum of variances of the required loadings of the factor matrix within factors, across variables". "The spread in loadings is maximized – loadings that are high after extraction become higher after rotation and loadings that are low become lower" (Tabachnick and Fidell, 2001). The extraction method used to extract the components was firstly based on the eigenvalue being greater than or equal to one and secondly, the factors accounting for a minimum 60.0 % of the variance. Using the eigenvalue for establishing a cutoff is the most reliable when the number of variables is between 20 and 50 (note that the present research has 45 variables) (Hair et al., 2006).

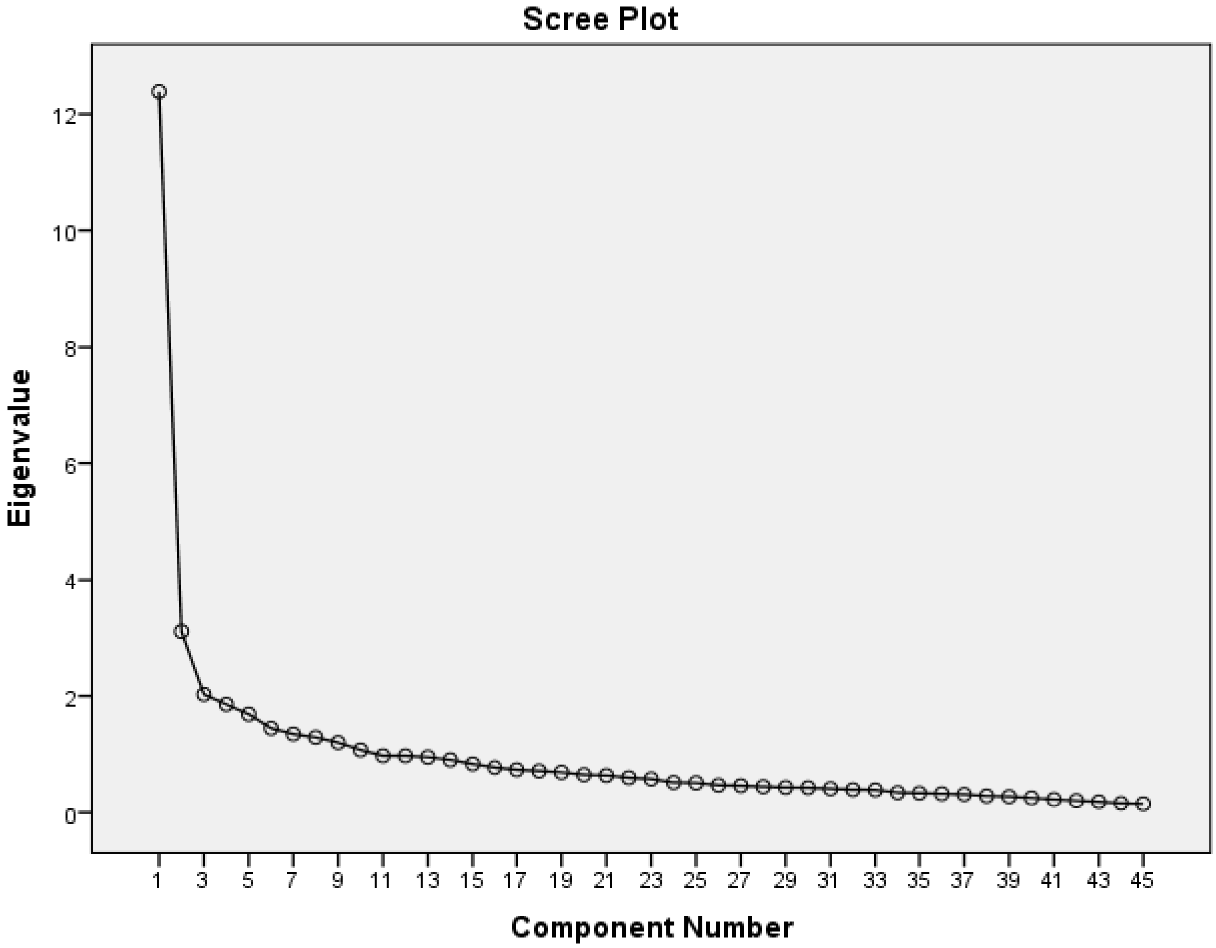


Figure 8.1 A Scree Plot

It is also important to look at the scree plot from an analysis of principal components as shown in Figure 8.1. According to Chua (2009), this scree plot enabled a researcher to determine the number of factors easily. There was a change (or elbow) in the shape of the plot to be looked for. The elbow appears to be around component 3, but component 3 corresponds to eigenvalue equals of 2.0. Therefore, components 4 to 13 explained or captured much more of the variance than the remaining components. So, only ten components (i.e. components 4 to 13) were retained or extracted from this scree plot. In addition to that, the plot showed that only ten components had eigenvalues exceeding 1. The incremental variance explained continued to decrease beyond ten factors, namely, after components 13 up to 45.

The results provided statistical evidence to support identified and explored determinants of rail service quality attributes as being ten factors. These 45 rail service quality attributes had gone through the factor analysis performance, which was the principal component analysis (PCA) and a rotation was used and the method adopted was the varimax with a kaiser normalization to produce ten components. This factor analysis according to Daly et al. (2012) analyses the interrelationships between rail service quality attributes and the PCA statistically transforms the correlated attributes into a satisfactory number of uncorrelated variables called principal components. Parasuraman et al. (1988, 1991) as cited by Low (1994) used oblique rotation for extraction of the factors. The varimax rotation was used because it provides a clearer separation of factors and collinearity is eliminated (Low, 1994). Kaiser normalization is the same as Kaiser criterion as defined by Pallant (2010). The varimax rotation was developed by Kaiser (Muhamad Nazri et al., 2014) and that Kaiser criterion refers to retaining all components with eigenvalues above 1 where the IBM SPSS uses the Kaiser criterion as a default. This varimax analysis resulted in a rotated component matrix and that rotation converged in ten iterations.

The standardized factor loadings were extracted from a table of a rotated component matrix. A factor loading benchmark of 0.50 was used for validity when the factor analysis model produced the factor distribution. As a result, the extraction method used to iteratively extract the factors (components or variables) from the distribution was based on components exceeding 0.50 for each iteration. These ten factors (iterations) were labelled and named with new variables referring to corresponding nature of 37 items that were retained due to they had values of factor loadings greater than 0.50. The other 8 items had values of factor loadings lesser than 0.50, meaning they had been rejected from the list. For example, items such as service frequency, schedules and reliability or punctuality were felt by the researcher describing the efficiency of train. Therefore, these items were labelled as a factor, F3 and were named as Train Efficiency. So happened to items such as environmental friendliness, comfort of train coach (interior), air-conditioning in train coaches, cleanliness of train coaches, seat, litter bins, fully covered platforms and cleanliness of platforms and stations were all describing the ambience of train. Thus, these items were labelled as a factor, F1 and were named as Train Ambience. The name of a factor was chosen based on the nature of the items. The new ten factors, factor loading and reliability value (alpha Cronbach) for each item are listed in Table 8.3.

Table 8.3 Name of Factors

Naming of Factors		Name of the Items	Factor Loadings (Croncbach's Alpha)
F1	Train Ambience	Environmental friendliness	0.528 (0.858)
		Comfort of train coach (interior)	0.582 (0.858)
		Air-conditioning in train coaches	0.542 (0.858)
		Cleanliness of train coaches	0.699 (0.858)
		Seat	0.680 (0.858)
		Litter bins	0.578 (0.858)
		Fully covered platforms	0.605 (0.858)
		Cleanliness of platforms and stations	0.686 (0.858)
F2	Ticketing, Information and Station Entry-Exit System	Turnstile	0.685 (0.773)
		Ticket counters	0.706 (0.773)
		Ticket vending machines	0.666 (0.773)
		Electronic ticketing system	0.588 (0.773)
		Route time clock	0.508 (0.773)
F3	Train Efficiency	Service frequency	0.772 (0.884)
		Schedules	0.819 (0.884)
		Reliability or punctuality	0.848 (0.884)
F4	Parking Facilities	Number of retail outlets	0.597 (0.833)
		Parking lots	0.851 (0.833)
		Park-and-ride capacity	0.872 (0.833)
		Kiss-and-ride size	0.800 (0.833)
F5	Station Quality	Station/stop quality	0.532 (0.711)
		Station lightings	0.708 (0.711)
		Safety Equipment	0.505 (0.711)
F6	Fares and People Services	Staff Courtesy	0.678 (0.762)
		Customer services	0.700 (0.762)
		Fares	0.693 (0.762)
F7	Facilities	Toilets, showers and prayer rooms	0.503 (0.608)
		Baby-changing facilities	0.523 (0.608)
		Telephones	0.591 (0.608)
		Suggestions & complaints management systems	0.530 (0.608)
F8	Extra Facilities	Facilities for the handicapped groups	0.642 (0.563)
		Facilities for parent(s) including small children	0.734 (0.563)
		Feeder bus services	0.597 (0.563)
F9	Space Comfort	Availability of seats	0.799 (0.817)
		Standing space	0.793 (0.817)
F10	Rail Structures	Transfer facilities	0.728 (0.690)
		Overhead bridge	0.721 (0.690)

Ten new variables were generated by multiplying the standard scores or z-scores with factor loadings of items that formed each of the new variables. First, "the purpose of z-scores was to identify and describe the exact location of every score in a distribution" (Gravetter and Wallnau, 2009). What happened here was that the X values were transformed into z-scores so that the resulting z-scores depicted the location of the original X scores exactly within the distribution. Standard scores were then used to standardize the entire distribution in particular the unit of those data so that they could be directly compared to other distributions that were also transformed into z-scores. These standard scores can simply be generated from a specific command in the Descriptives under the Descriptive Statistics of the IBM SPSS programme. "The sign of the z-score (+ or -) signifies whether the score is above the mean (positive) or below the mean (negative)" (Gravetter and Wallnau, 2009). This process of generation of new variables also made up for data screening i.e., to check whether the data made sense or not. These ten new variables were known as standardized factor scores. Each of the new variables was computed by a specific formula in Microsoft Excel because it depended on the number of items that formed each of the new variables. In other words, each of the new variables was computed by multiplying the standard scores or z-scores with factor loadings of items that formed each of the new variables.

These ten new variables (factors) were labelled with the same names as shown in Table 8.3, such as Train Ambience, Ticketing, Information and Station Entry-Exit System, Train Efficiency, Parking Facilities, Station Quality, Fares and People Services, Facilities, Extra Facilities, Space Comfort and Rail Structures. The name of factor was given based on the nature of the items of each factor. For example, service frequency, schedules and reliability or punctuality are technically the features of train efficiency. So, that is where Factor F3 gets its name. Fares were connected to people services because the link was given by the results of the factor analysis. The same happened to a number of retail outlets where they were linked to parking facilities due to the factor loading being grouped together under the factor namely parking facilities.

At the end of the output, the ten Component Transformation Matrix are indicated in Table 8.4. The extraction and rotation methods were Principal Component Analysis and Varimax with Kaiser Normalization respectively. This provided strength of relationship between the ten factors. With reference to Chua (2009), this Component Transformation Matrix indicated that correlation between the ten factors was moderate, with all correlations below 0.70 (the strength of correlation was between 0.138 and 0.653). This meant that all the ten factors were 'free' of one another, concluding that these ten factors can act as ten different constructs.

Table 8.4 Component Transformation Matrix

Component	1	2	3	4	5	6	7	8	9	10
1	0.520	0.398	0.367	0.220	0.322	0.303	0.288	0.144	0.206	0.215
2	-0.356	0.136	-0.230	0.742	-0.123	-0.080	0.208	0.382	-0.142	0.141
3	-0.296	0.026	0.721	-0.154	-0.072	-0.433	-0.066	0.398	0.107	0.032
4	0.366	-0.836	0.120	0.318	0.077	-0.169	0.084	0.054	0.078	0.030
5	0.138	-0.095	-0.280	-0.493	-0.033	-0.028	0.552	0.539	-0.227	0.029
6	-0.238	-0.013	-0.324	-0.084	0.348	-0.229	0.152	-0.002	0.793	0.080
7	0.266	0.129	-0.066	0.119	-0.348	0.015	-0.082	0.269	0.319	-0.769
8	-0.428	-0.205	0.194	0.022	0.506	0.452	0.181	0.035	-0.128	-0.476
9	0.155	0.032	-0.226	-0.020	0.476	-0.045	-0.667	0.477	-0.144	0.037
10	-0.163	-0.235	0.036	-0.101	-0.381	0.653	-0.223	0.282	0.318	0.324

8.3 STATISTICAL MODELLING

In this work, *KTM Komuter* quality of services were analyzed by developing several indices to evaluate *KTM Komuter* service quality which was to determine how much weight passengers gave to each attribute when making a global assessment of service quality. A detailed and relevant number of support facilities were also evaluated.

8.3.1 The SEM method with Analysis of Moment Structures (AMOS) Graphics and programme (software)

This research applied 'the most complete and robust statistical techniques' i.e. SEM (Homem de Almeida Correia et al., 2013, Saodah, 2014) applying AMOS software which is an advancement involving factor analysis, principal component analysis and path analysis. SEM has an advantage compared to the traditional regression modelling in that it adopts a multivariate technique incorporating a series of formal models and the corresponding parameter estimates (Khoo and Ong, 2015). The following descriptions of SEM were extracted from the data analysis method of Chou and Kim (2009). SEM was a contemporary second generation multivariate analytic technique. It began in the1970s. It is widely applied in psychology-, education-, management-, social sciences-, health sciences- (Irfan et al., 2012; Homem de Almeida Correia et al., 2013) and travel behavioural-related research in particular a variety of travel demand modelling (Khoo and Ong, 2015). It is a confirmatory method that evaluates causal relationships between the constructs of a model. The measurement model assesses latent (unobserved) variables as linear functions of indicators (observed variables). The structural model shows the direction and strengths of the relationships of the latent variables. Irfan et al. (2012) stated that SEM models are presented by a graphical path diagram.

All SEM estimation methods require a sample size of at least 200 to reduce biases satisfactorily (Golob, 2003, Chou and Kim, 2009, Muhamad Nazri et al., 2014). In this way, the current sampled size indicated SEM can be employed to model and analyze the empirical data with regard to the theoretical relationships for the *KTM Komuter* system.

To conduct the SEM method meant actually conducting a CFA. All factors are to be analysed simultaneously using SEM. This CFA was further divided into the First Order CFA and the Second Order CFA. There are three types of models, namely the measurement model, structural model and default model. The default model is a pre-determined model which acts as a baseline and this is the one AMOS uses. The Saturated model is a model that hypothesizes that everything is related to everything (just identified) and the Independence model is a model that hypothesizes that nothing is related to anything. Through the First Order CFA, the factor structure or the measurement model was confirmed by estimating the model evaluation. The model evaluation included replotting the model fit and goodness of fit indices if the particular items represented different factors (constructs). So, the measurement model fit is assessed by the CFA. The Second Order CFA involved the convergent and discriminant validity tests of a CFA measurement model. This was done by calculating the values of Construct Reliability (CR), Average Variance Extracted (AVE) and Discriminant Validity. Then, a structural model was developed to test and evaluate the significance and strength of each path in the model. The above data analysis was a complete approach to estimate the validity of the construct and to evaluate whether the structural model fitted the theoretical model and was acceptable (Muhamad Nazri et al., 2014).

Summary of the First Order CFA

1) Draw the model (i.e. factors and the corresponding items);
2) Select one object at a time;
3) Select the factors one by one;
4) Select Plug ins (on the top menu of the AMOS software) and then select Draw Covariances;
5) Select Analysis Properties to run the input;
6) Select Calculate Estimates to run the programme;
7) Select View Text, go to Model Fit and check for the indices requirements;
8) Rearrange the factor loadings for the items of the factors; if it is lesser than 0.6, the corresponding item must be deleted because of a pre-established scale or instrument from the aspect of unidimensionality (Hair et al, 2006) i.e. they were developed through a thorough literature review;
9) Go to the Model Fit;
10) Recheck the indices after running the input;
11) Go to Estimates to check for the values of the factor loadings of the items;
12) Repeat step (8) one by one for the factors.

Items such as air-conditioning in train coaches, fares, toilets, shower and prayer rooms, baby-changing facilities and feeder bus services were deleted from the path diagram of the first order CFA model because their values of factor loadings were lesser than 0.60 – 0.70 and the modification indices associated with some of the items were high (greater than 10).

Referring to the final structural model of the First Order CFA in Figure 8.2, there were only nine factors namely, train ambience, ticketing, information and station entry-exit system, train efficieny, parking facilities, station quality, people services, facilities, space comfort and rail structures. In addition to that, train ambience comprised seven items such as environmental friendliness, comfort of train coach (interior), cleanliness of train coaches, seat, litter bins, fully covered platforms and cleanliness of platforms and stations. People services consisted of only two items i.e., staff courtesy and customer services and similarly, only two items i.e., telephones and suggestion and complaint management system made up facilities. Suggestion and complaint management system referred to the ‘soft’ aspect of facility since Brons and Rietveld (2009) concluded that comfort, information services and personal safety mainly explain the ‘soft’ dimensions. Ticketing, information and station entry-exit system was defined by turnstile, ticket counters, ticket vending machines, electronic ticketing system and route time clock. Also, from the path diagram, train efficiency was formed by ‘hard’ or easily measurable items such as service frequency, schedules (timetable) and reliability or punctuality whereas parking facilities comprised number of retail outlets, parking lots, park-and-ride capacity and kiss-and-ride size. Path diagrams are schematic representations of models, which show a visual portrayal of relations which are assumed to hold among the variables under study (Byrne, 2010). Station quality was further defined by station/stop quality, station lightings and safety equipment. Items of space comfort were known as availability of seats and standing space while items like transfer facilities and overhead bridge referred to the rail structures.

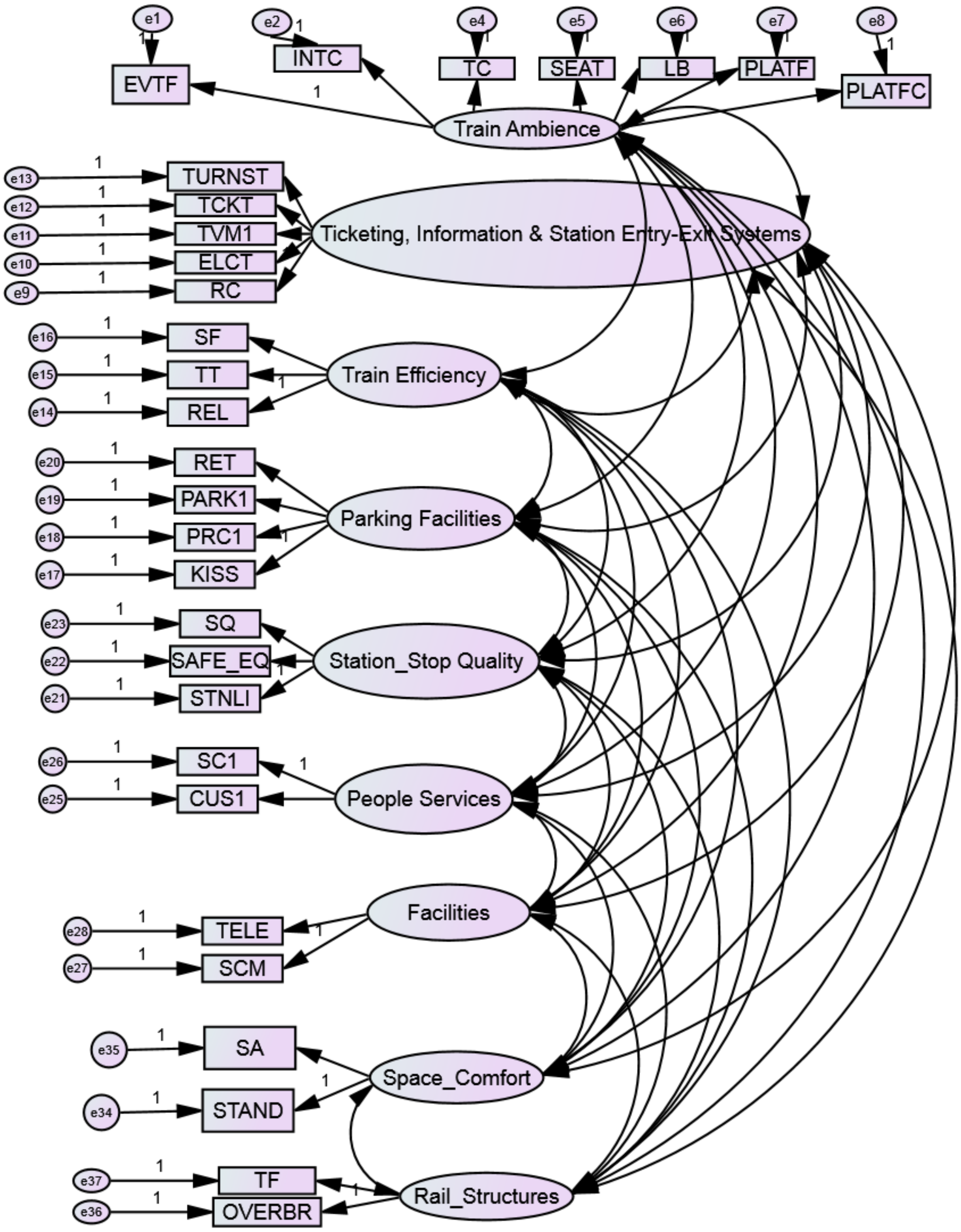


Figure 8.2 The Final Model of the First Order CFA

Summary of the Second Order CFA

1) Draw the unobserved variables;
2) Name ________Service_Quality;
3) Select the single headed arrow;
4) From the Service_Quality, drag it to all constructs (factors) one by one;
5) Include the constraints by selecting the univariable to an existing variable;
6) Include the constraints to all the constructs;
7) Name the error terms;
8) Select Plug ins;
9) Select and name the unobserved variables;
10) Double click on the Service_Quality;
11) Go on parameters on Object Properties Window;
12) Include 1 in the box of Variance (at the bottom of the window);
13) Close the Object Properties Window.

Before interpreting the results, readers will need to know the definition of CR and AVE. Construct Reliability (CR) is a measure of reliability and internal consistency based on the square of the total of factor loadings for a construct. Average Variance Extracted (AVE) is a number that provides an indication of the convergent validity. Reliability should be 0.70 or higher to indicate adequate convergence or internal consistency. All the estimates are statistically significant if the probability value, P value is less than 0.05 (* means 0.001 i.e., significant). All loadings should be at least 0.50 and preferably 0.70 or higher. Let's say parking lots have a factor loading below 0.50 (i.e. 0.372), hence, this factor of parking lots cannot be included in the convergent validity calculations.

Referring to the final structural model of the Second Order CFA in Figure 8.3, facilities (0.83) was the extreme factor for high *KTM Komuter* service quality, which meant the factor facilities compared to all of the factors weighed more towards high rail service quality. This was followed by factors such as train ambience (0.81) and station quality (0.81), ticketing, information and station entry-exit system (0.77), people services (0.75), rail structures (0.59), space comfort (0.57), train efficiency (0.56) and parking facilities (0.37).

Deutsch et al. (2013) noted good model fit criteria including Standardized Root Mean Square Residual (SRMR) values 0.08 or below, Root Mean Square Error of Approximation (RMSEA) values 0.06 or 0.05 below (Golob, 2003), and Comparative Fit Index (CFI) values 0.95 or greater. Looking into the model fit (goodness-of-fit statistics for the resulting SEM) summary, the model had a good fit because of these values i.e., the minimum discrepancy (CMIN)/degree of freedom (DF) which was 2.106 (lesser than 3.0), the Goodness-of-Fit Index (GFI) was 0.874 (approximately 0.90), the Tucker-Lewis Index (TLI) was 0.904 (greater than 0.90), the Comparative Fit Index (CFI) was 0.913 (greater than 0.90) and the root mean square error of approximation (RMSEA) was 0.053 (lesser than 0.06). The views of Golob (2003), Cao et al. (2007) and Chou and Kim (2009) on a rule of thumb for the value of each of these preceding indices for a good model should be more than 0.90 but less than 1.00. Goodness of Fit indicates how well the specified model reproduces the covariance matrix among the indicator variables that is, it examines the similarity of the observed and estimated covariance matrices. All of these measures produced supportive indices, suggesting that the *KTM Komuter* data fitted the model well.

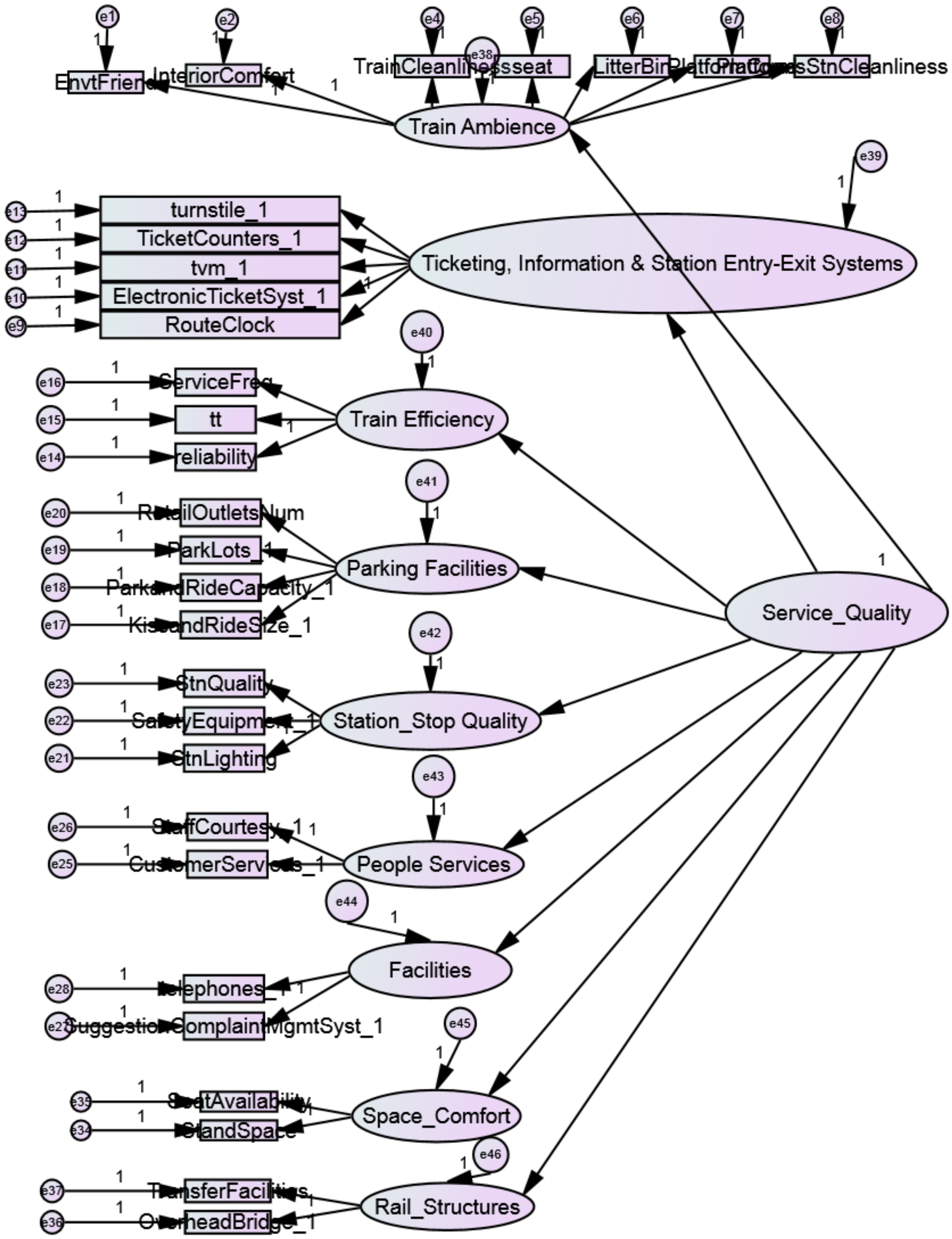


Figure 8.3 The Final Model of the Second Order CFA

Under the AMOS Output for the structural model, one must go to modification indices (MI) and then proceed to Estimates to check for the validity of the constructs. Construct validity is the extent to which a set of measured items actually reflect the theoretical latent construct they are designed to measure. Cleanliness of train coaches (0.739) was the most important item for the factor train ambience. This was followed by seat (0.712), cleanliness of platforms and stations (0.695), fully covered platforms (0.671), environmental friendliness (0.656), comfort of train coach interior (0.616) and litter bins (0.550). Ticket counters (0.743) were the most important item related to the ticketing, information and station entry-exit system factor. Schedules with a standardized factor loading of 0.896 gave the greatest impact on train efficiency. This was followed by reliability or punctuality (0.872) and service frequency (0.784). Park-and-ride capacity (0.901) was a dominant item in the parking facilities. So were the station lightings with 0.700 in the station quality. Customer services (0.876) had the greatest impact on people services. While the suggestion and complaint management system (0.709) led the other items in the facilities. Standing space (0.871) was the most significant item for space comfort factor whereas transfer facilities (0.761) defined the rail structures significantly.

Summary of Convergent Validity Test

1) Go to View Text (next to SAVE) and select model fit;
2) Go to Estimates;
3) Go to Standardized Regression Weights, look at the first factor: Ambience, go back to excel, write Ambience at the spreadsheet;
4) Find Item reliabilities, write in a column the squared standardized factor loadings, for example, $(0.656)^2$, write the formula = B2*B2;
5) Calculate the Average Variance Extracted (AVE)

$$\text{AVE} = \left(\frac{\sum_{i=1}^{n} \lambda_i^2}{n} \right),$$

where, λ = factor loadings;

$\sum_{i=1}^{n} \lambda_i^2$ = the sum of the squared loadings;

n = number of items in a given factor

6) (AVE ≥ 0.5) means high convergent validity and for those below 0.5, they show very low AVE, which thus depict very low convergent validity;

7) Calculate Construct Reliability, CR

$$\text{CR} = \frac{\left(\sum_{i=1}^{n} \lambda_i \right)^2}{\left(\sum_{i=1}^{n} \lambda_i \right)^2 + \left(\sum_{i=1}^{n} \delta_i \right)};$$

where, δ = error term;

λ = factor loadings;

n = number of items in a given factor

8) Error term, δ = (1 – Item Reliabilities);

9) ∑δ is a summation of each construct;

10) The rule of thumb for a construct reliability estimate is that 0.7 or higher suggests good reliability. Reliability between 0.6 and 0.7 may be acceptable provided that the other indicators of a model's construct validity are good. A

high construct reliability indicates that internal consistency exists. This means all the measures are consistently representing something.

Convergent Validity is the extent to which indicators of a specific construct 'converge' share a high proportion of variance in common. To assess convergent validity, factor (construct) loadings for each item are examined, average variance extracted (AVE) and construct reliabilities (CR) for each construct are ensured to exceed 0.50 (Muhamad Nazri et al., 2014). When the value of factor loading for an item was less than 0.50, that item was dropped from further analysis. Both the AVE and CR are NOT provided by the AMOS software. So, they had to be calculated on a spreadsheet (using Microsoft Excel).

Table 8.5 Summary of Results of Convergent Validity Test

Factors and Items	Factor Loadings	Construct Reliability (CR)	Average Variance Extracted (AVE)
Train Ambience (n=7); Cleanliness of train coaches; Seat; Cleanliness of platforms and stations; Fully covered platforms; Environmental friendliness; Comfort of train coach (interior); and Litter bins	 0.739 0.712 0.695 0.671 0.656 0.616 0.550	0.847	0.443
Ticketing, Information and Station Entry-Exit System (n=5); Ticket counters; Ticket vending machines; Electronic ticketing system; Route time clock; and Turnstile	 0.743 0.717 0.635 0.559 0.549	0.779	0.417
Parking Facilities (n=4); Park-and-ride capacity; Parking lots; Kiss-and-ride size; and Number of retail outlets	 0.901 0.860 0.770 0.520	0.854	0.604
Train Efficiency (n=3); Schedules; Reliability or punctuality; and Service frequency	 0.896 0.872 0.784	0.888	0.726
Station Quality (n=3); Station lightings; Station/stop quality; and Safety equipment	 0.700 0.681 0.645	0.716	0.457
People Services (n=2); Customer services; and Staff courtesy	 0.876 0.847	0.852	0.742
Facilities (n=2); Suggestion & Complaint Management System; and Telephones	 0.709 0.517	0.550	0.385
Space Comfort (n=2); Standing space; and Seats availability	 0.871 0.793	0.819	0.694
Rail Structures (n=2); Transfer facilities; and Overhead bridge	 0.761 0.698	0.700	0.533

Table 8.5 clearly identifies key areas for interventions on the transport system that are parking facilities, train efficiency, people services and space comfort from the high values of factor loading for each of the items. It can be said that park-and-ride capacity should be provided at other commuter rail stations. Additional car parking facilities should also be provided at other commuter rail stations to attract car users to use KTM Komuter every day. The parking cost should be reasonable. Kiss-and-ride size should be increased at other commuter rail stations too to attract more car and motorcycle passengers to ride KTM Komuter daily. However, the number of retail outlets needs no improvements because its factor loading was among the lowest. Train efficiency, schedules, reliability or punctuality and service frequency need improvements meaning additional trains should be operated for rationale schedules, reliability and service frequency to better serve the passengers. The values of factor loading of customer services and staff courtesy were among the highest, suggesting that these items should be improved by providing e-counter services and etiquette training for the KTMB staff. The factor loadings of standing space and seats availability also gave indications of those improvements should be done to these items. Improvements should cater for standing space and availability of seats by providing train coaches that are spacious. Seats availability for pregnant women, small children, disabled people and elderly people should be enhanced too. Suitable seats at the waiting areas are additional aspects to be looked into.

8.4 CONCLUSIONS

It can be concluded that SEM demonstrated a good fit with multiple measures and that the proposed final models could be useful to transport agencies, rail operators and transport planners to analyze the correlation between service quality attributes and to identify the most convenient attributes for improving supplied services. The estimated factor loadings from the Convergent Validity Test can be interpreted as weights that represent the importance of each factor. Therefore the main findings (see Table 8.5) are that the convergent validity of the measurement model appears to be adequate and major service characteristics like parking facilities, train efficiency, people services and space comfort have the highest positive effect on service quality. Based on Table 8.5, it is clear that these four factors have high values for both CR and AVE. This can provide valuable clues to the *KTM Komuter* management team in the process of evaluating alternative service improvements aimed at enhancing passenger satisfaction and comfort, and increasing market share through Market Analysis projects (Chou and Kim, 2009; de Oña et al., 2012). These major service characteristics are considered high priorities for *KTM Komuter* as the one and only regional commuter rail that can challenge users' dependency on cars (Transportation Research Board, 2013) and enable service quality to meet passenger expectations (Muhamad Nazri et al., 2014).

CHAPTER 9 : RESULT: OPTIMISATION MODELS (FOR PORT KLANG-SENTUL CORRIDOR)

9.1 INTRODUCTION

Improving customer service means increasing speed, reliability and consistent delivery frequency. If users dislike crowding, the inclusion or omission of the crowding cost influences the optimal values of the ‘hard’ elements such as accessibility, service frequency, vehicle size, service schedule (travel time reliability) and fare level, among other supply side variables (Tirachini et al., 2013; Brons and Rietveld, 2009). The illustrative calculations and the illustration results of the Optimisation Models are discussed in detail in this chapter even though there were eleven cases for KL Inbound’s evening peak and nine cases for KL Outbound’s evening peak. The evening peaks (1630 – 2030 hours) were of interest to the researcher because these periods demonstrated a high train supply and passenger demand. Siti Nurbaya et al. (2013) stated that the selection of the evening peaks were also worsened by so many technical faults of train and overcrowding at platforms and coaches in accordance with the *KTMB*’s Customer Satisfaction Survey in 2004. KL Inbound means city travel for the commuter train from Port Klang to Sentul whereas KL Outbound refers to the opposite direction. There were six cases for morning peak (0630 – 0930) and five cases for afternoon peak (1130 – 1430) for KL Inbound to capture data on passenger per hour, P_L through the Passenger Onboard Surveys. For the KL Outbound direction, there were six cases for both morning and afternoon peaks. The cases were not similar because the researcher had to conduct the surveys herself to capture the scenes over seven time variations (different periods over a day) which was from 0500 to 2400 every day and for both ways. The researcher encountered difficulties to multitask and allocate survey timing individually. However, these cases for both directions were sufficient to draw meaningful conclusions. Then, timetables from the optimised results for the seven time periods were developed for optimal rail quality services for both directions.

9.2 HEADWAY

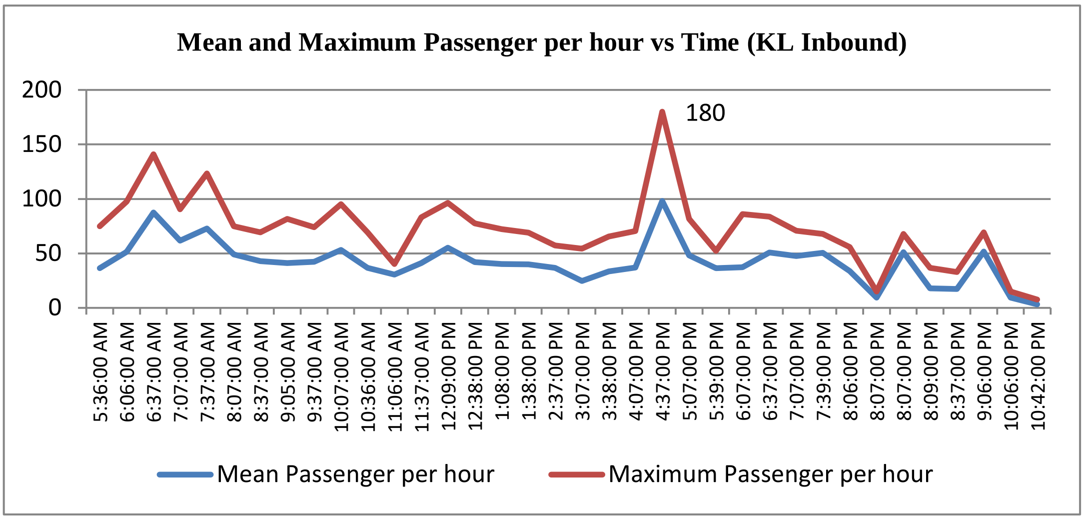


Figure 9.1 Mean and Maximum Passenger per trip per hour vs Time for KL Inbound

There are two identical graphs in Figure 9.1. The red line represents the maximum passenger per trip per hour whereas the blue line shows the mean passenger per trip per hour. Both of them depict the same pattern, but of course the red line is expected to be higher than the blue line. The shape of the trend notes an escalating trend where there are approximately ten peaks hours, commencing 6.37

am, 7.37 am, 9.05 am, 10.07 am, 12.09 pm, 4.37 pm, 6.07 pm, 7.39 pm, 8.07 pm to 9.06 pm. The major peak hour is at 4.37 pm which recorded 180.0 maximum passengers per trip per hour. Meanwhile, there are about eleven troughs. The source of the data is based on On-Board Surveys. The current research was able to analyse this variable that is the maximum passenger per trip per hour by using Microsoft Excel software. This analysis was conducted to deliberately measure and investigate passenger demand at certain times, to determine the shortest commuter train travel time in terms of the shortest service frequency and to gauge the highest train composition during operations in terms of a high number of train volume. The main findings from the site observations and measurements reveal that there are two categories of peak period for KL Inbound. The first category involves a combination of the morning peak hours, late comers and afternoon peak periods i.e. from 0630 to 1230 whilst the second category of peak period consists of evening peak times and a small portion of off peak period i.e. from 1630 to 2130. In other words, these two categories of peak period for KL Inbound should be designed with the shortest service headway and be equipped with the highest number of train because they indicate a relatively high demand from the commuting passengers per trip per hour. Therefore, *KTMB* should look into adding more trains for these peak hours/services to reduce crowding (Douglas and Karpouzis, 2009).

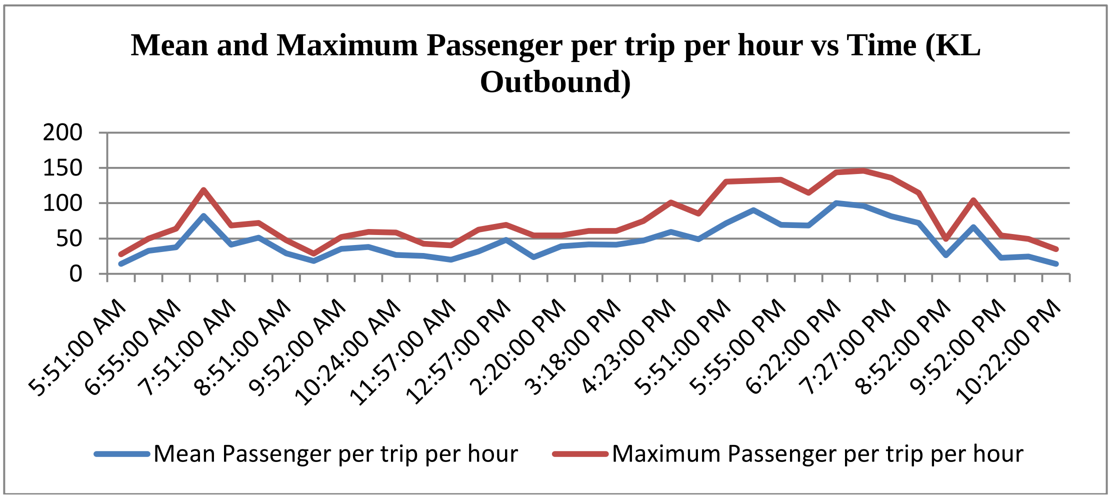


Figure 9.2 Mean and Maximum Passenger per trip per hour vs Time for KL Outbound

Figure 9.2 also shows two identical graphs. The red line represents the maximum passenger per trip per hour whereas the blue line shows the mean passenger per trip per hour. Both of them depict the same pattern with the same time frame, but of course the red line is expected to be higher than that of the blue line. The trend increases where there are approximately nine peak periods, starting 7.20 am, 8.22 am, 10.22 am, 12.57 pm, 4.23 pm, 5.51 pm, 5.55 pm, 6.52 pm to 8.56 pm. The major peak hour is at 6.52 pm which recorded 145.7 maximum passengers per trip per hour. Meanwhile, there are about eight troughs. The source of the data is based on On-Board Surveys. The current research was able to analyse this variable that is the maximum passenger per trip per hour ‘stochastically’ by using Microsoft Excel software. This analysis is conducted to deliberately measure and investigate the passenger demand for certain time, to determine the shortest commuter train travel time in terms of the shortest service frequency and to identify the highest train composition during operations in terms of a high number of train volume. The main findings from the site observations and measurements are there are three categories of peak periods for KL Outbound travelling. The category involves morning peak period i.e. from 0630 to 0930. The second category of peak period consists of late comers and afternoon peak periods i.e. from 1000 to 1300. Meanwhile, the third category involves a combination of early release, evening peak and part of the off peak period periods i.e. from 1600 to 2100. In other words, these three categories of peak periods for KL Outbound should be designed with the shortest service headway and highest number of trains because these three categories of peak periods for KL Outbound showcased a high demand from commuting passengers per trip per hour. Therefore, *KTMB* should look into these peak services to reduce crowding effectively and efficiently.

The statistical computations in the spreadsheet resulted in mean, median, maximum and minimum passengers per trip per hour up to eleven and nine cases for the corresponding KL Inbound and KL Outbound directions from the data of Passenger On-Board Counting Surveys. However, only maximum passenger per trip per hour was used in the following formulae for a conservative approach.

R17 =SQRT((120*D17*E17)/(F17*G17))

Maximum Passenger per hour, PL (KL Inbound)

	Time		2010															
			Cycle Time,T (minutes)	Co	Cp	PL1	PL2	PL3	PL4	PL5	PL6	PL7	PL8	PL9	PL10	PL11	h1*	h2*
17	1	Early Birds (0500 - 0630)	298	662	80	2700	3516										10.5	9.2
18	2	Morning Peak (0630 - 0930)	298	662	80	2941	3253	4441	5075	2700	2496						10.0	9.5
19	3	Late Comers (0930 - 1130)	268	662	80	2494	2660	1448	3431								10.3	10.0
20	4	Afternoon Peak (1130 - 1430)	258	662	80	2789	2597	2993	3467	2484							9.6	9.9
21	5	Early Release (1430 - 1630)	320	662	80	2533	2066	1958	2359								11.2	12.4
22	6	Evening Peak (1630 - 2030)	284	662	80	540	2546	2004	1323	3015	6480	2443	2935	2445	1876	3100	22.9	10.5
23	7	Off Peak (2030 - 2400)	242	662	80	534	270	1185	2500								21.2	29.8

Note:
Co = Hourly Cost of TU operation
Cp = Hourly Cost of Passenger Waiting Time
h* = Optimal Headway

Figure 9.3 An Illustrative Calculation of An Optimal Headway, h_1^* at cell R17

(marked yellow) for the Early Birds for KL Inbound

Table 9.1 Optimal Headways, h* for Different Maximum Passenger per trip per hour for KL Inbound for 2010

	Time	Optimal Headways, h* for Different Maximum Passenger per hour for KL Inbound for 2010										
		h1*	**h2***	**h3***	**h4***	**h5***	**h6***	**h7***	**h8***	**h9***	**h10***	**h11***
1	Early Bird Travellers (0500 - 0630)	10.5	9.2									
2	Morning Peak Hours (0630 - 0930)	10.0	9.5	8.2	7.6	10.5	10.9					
3	Late Comers (0930 - 1130)	10.3	10.0	13.6	8.8							
4	Afternoon Peak Hours (1130 - 1430)	9.6	9.9	9.3	8.6	10.2						
5	Early Release (1430 - 1630)	11.2	12.4	12.7	11.6							
6	Evening Peak Hours (1630 - 2030)	22.9	10.5	11.9	14.6	9.7	6.6	10.7	9.8	10.7	12.3	9.5
7	Off Peak Periods (2030 - 2400)	21.2	29.8	14.2	9.8							

Figure 9.3 shows the calculation of an optimal headway, h_1^* at cell R17 (marked yellow) for the Early Birds for KL Inbound direction. It is calculated using formula (3.2), $h^* = \sqrt{\frac{120.T.c_O}{P_L \cdot c_p}}$. This formula was derived in Chapter 3, under Section 3.6.1(a) on page 109. This figure also shows maximum passenger per trip per hour up to eleven cases subject to data availability from the Passenger Counting Surveys and cycle time obtained from field measurement. Cycle time is one of the physical information of *KTM Komuter* that to some extent describes the usage of *KTM Komuter* services. Overall, the optimal values of headway in Table 9.1 range from 6.6 to 29.8 minutes for seven time variations based on visual observations. With further reference to Figure 9.4, during peak periods including the morning, afternoon and evening peak periods, the optimal values of headway range from 6.6 to 22.9 minutes. However, the details about the optimal headways for morning peak periods are from 7.6 to 10.9 minutes whereas the details about the optimal headways for afternoon peak period are from 8.6 to 10.2 minutes. The average value of the optimal headway for morning peak period is 9.45 minutes. The average value of the optimal headway for afternoon peak period is 9.52 minutes. The evening peak period has eleven readings for the optimal headways that range from 6.6 to 22.9 minutes. The average value of the optimal headway for evening peak period is 11.75 minutes. During inter-peak periods, the optimal values of headway differ from 8.8 to 13.6 minutes. The inter-peak periods are categorised by the periods of late comers and early release. The average value of the optimal headway for late comers is 10.68 minutes whilst the average value of the optimal headway for early release is 11.98 minutes. For the early birds, there are only two readings recorded for the optimal headways and they are 9.2 and 10.5 minutes. The average value of the optimal headway for the early birds is 9.85 minutes. During the off peak period, the optimal values of headway range from 9.8 to 29.8 minutes. The average value of the optimal headway for the off peak period is 18.75 minutes. In conclusion, two categories of peak period for KL Inbound i.e. 0630 – 1230 and 1630 – 2130 should be designed with the shortest service headways at approximately 9.75 minutes and 15.25 minutes respectively. The early bird hour (0500 – 0630), inter-peak hours (1230 – 1630) and the remaining off peak periods (2130 – 2400) should be designed at 9.85 minutes, 10.75 minutes and 18.75 minutes respectively.

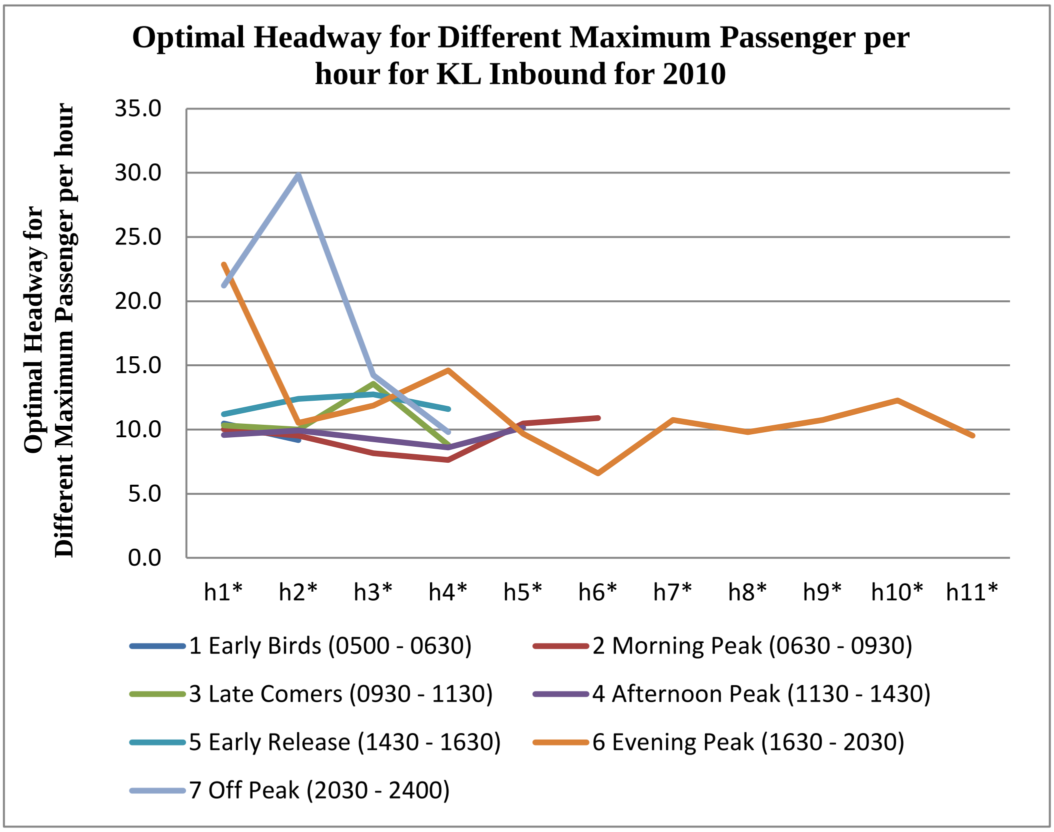


Figure 9.4 Optimal Headways for seven time variations for KL Inbound for 2010

P17 f_x =SQRT((120*D17*E17)/(F17*G17))

Maximum Passenger per hour, P_L (KL Outbound)

Time		2010													
		Cycle Time,T (minutes)	Co	Cp	P_{L1}	P_{L2}	P_{L3}	P_{L4}	P_{L5}	P_{L6}	P_{L7}	P_{L8}	P_{L9}	h_1*	h_2*
1	Early Birds (0500 - 0630)	278	662	80	1166	2100								15.4	11.5
2	Morning Peak (0630 - 0930)	284	662	80	4977	1998	2868	1200	3018	2678				7.5	11.9
3	Late Comers (0930 - 1130)	282	662	80	1782	2454	2182	2490						12.5	10.7
4	Afternoon Peak (1130 - 1430)	272	662	80	2626	2274	2277	2913	2551	1691				10.1	10.9
5	Early Release (1430 - 1630)	284	662	80	2547	3143	4249							10.5	9.5
6	Evening Peak (1630 - 2030)	302	662	80	5544	4808	5483	3583	6030	6120	5600	5700	4808	7.4	7.9
7	Off Peak (2030 - 2400)	320	662	80	2079	4370	2288	2072	1459					12.4	8.5

Note:
Co = Hourly Cost of TU operation
Cp = Hourly Cost of Passenger Waiting Time
h* = Optimal Headway

Figure 9.5 An Illustrative Calculation of An Optimal Headway, h_1^* at cell P17 (marked yellow) for the Early Birds for KL Outbound

Table 9.2 Optimal Headways, h* for Different Maximum Passenger per hour for KL Outbound for 2010

Time		**Optimal Headways, h* for Different Maximum Passenger per hour for KL Outbound for 2010**								
		h_1*	**h_2***	**h_3***	**h_4***	**h_5***	**h_6***	**h_7***	**h_8***	**h_9***
1	Early Bird Travellers (0500 - 0630)	15.4	11.5							
2	Morning Peak Hours (0630 - 0930)	7.5	11.9	9.9	15.3	9.7	10.3			
3	Late Comers (0930 - 1130)	12.5	10.7	11.3	10.6					
4	Afternoon Peak Hours(1130 - 1430)	10.1	10.9	10.9	9.6	10.3	12.6			
5	Early Release (1430 - 1630)	10.5	9.5	8.1						
6	Evening Peak Hours(1630 - 2030)	7.4	7.9	7.4	9.1	7.1	7.0	7.3	7.3	7.9
7	Off Peak Periods (2030 - 2400)	12.4	8.5	11.8	12.4	14.8				

Figure 9.5 illustrates the calculation of an optimal headway, h_1^* at cell P17 (marked yellow) for the Early Birds for KL Outbound direction. It is calculated

using formula (3.2), $h^* = \sqrt{\frac{120.T \cdot c_O}{P_L \cdot c_p}}$. This formula was derived in Chapter 3, under Section 3.6.1(a) on page 109. This figure also shows maximum passenger per trip per hour up to nine cases subject to data availability from the Passenger Counting Surveys and cycle time obtained from field measurement. This cycle time forms part of the physical information of *KTM Komuter*. In the same way in the result for KL Inbound, this cycle time also partly describes the usage of *KTM Komuter* services. Overall, Table 9.2 shows the optimal values of headway that range from 7.0 to 15.4 minutes for seven time variations based on visual observations. Back to Figure 9.6, during the peak periods including the morning, afternoon and evening peak periods, the optimal values of headway range from 7.0 to 15.3 minutes. However, the details about the optimal headways for morning peak period are from 7.5 to 15.3 minutes whereas the details about the optimal headways for afternoon peak period are from 9.6 to 12.6 minutes. The average value of the optimal headway for morning peak is 10.77 minutes. The average value of the optimal headway for afternoon peak is 10.73 minutes. The evening peak period has nine readings for the optimal headways that range from 7.0 to 9.1 minutes. The average value of the optimal headway for evening peak is 7.60 minutes. During the inter-peak periods, the optimal values of headway range from 8.1 to 12.5 minutes. The inter-peak periods are categorised by the periods of late comers and early release. The average value of the optimal headway for late comers is 11.28 minutes whilst the average value of the optimal headway for early release is 9.37 minutes. For the early birds, there are only two readings recorded for the optimal headways and they are 15.4 and 11.5 minutes. The average value of the optimal headway for the early birds is 13.45 minutes. During the off peak period, the optimal values of headway range from 8.5 to 14.8 minutes. The average value of the optimal headway for the off peak period is 11.98 minutes. In conclusion, three categories of peak period for KL Outbound i.e. 0630 – 0930, 1000 – 1300 and 1600 – 2100 should be designed with the shortest service headways i.e. approximately 10.75 minutes, 11.00 minutes and 9.65 minutes respectively. The early bird hour (0500 – 0630), inter-peak hours (1300 – 1600) and the remaining off peak periods (2100 – 2400) should be designed at 13.45 minutes, 10.05 minutes and 11.98 minutes respectively.

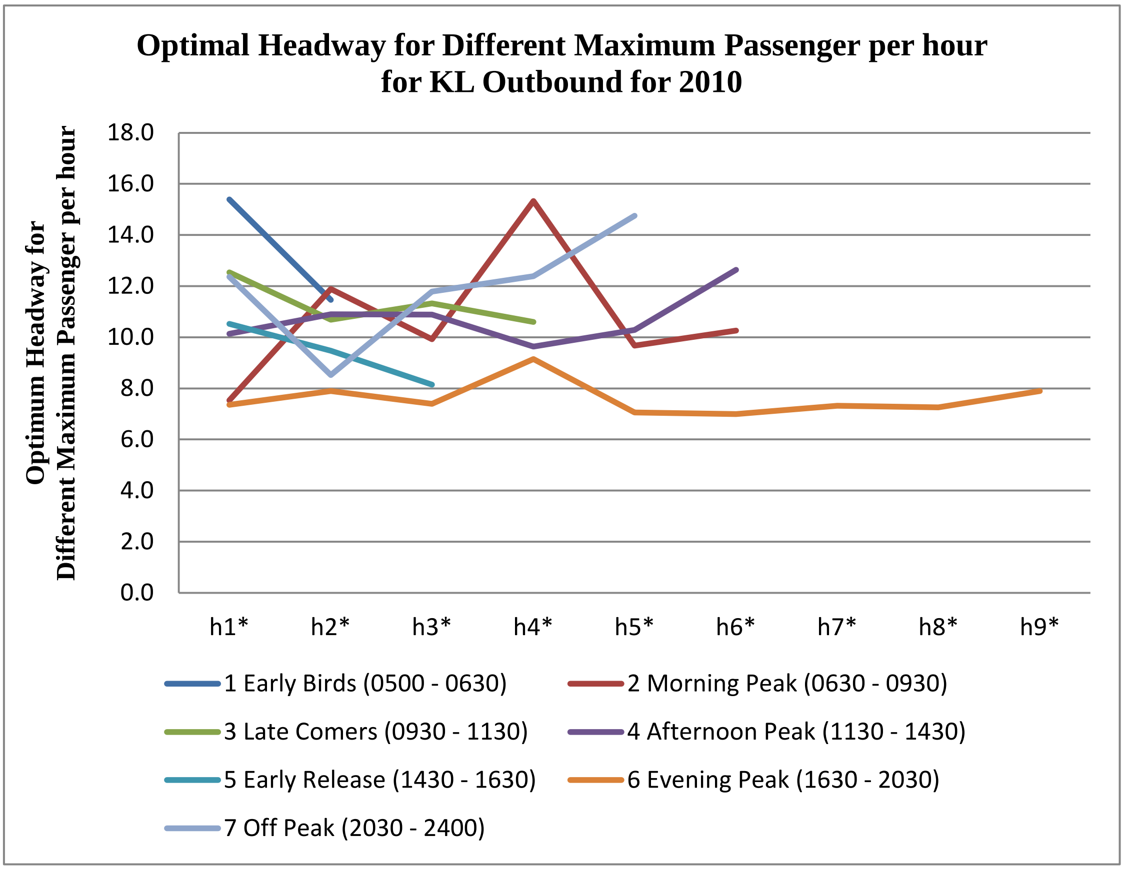


Figure 9.6 Optimal Headways for seven time variations for KL Outbound for 2010

The resulting sequential series of peaks demonstrate the need to offer temporal availability of commuter rail services to stations compared to the current concept of commuter rail, that is, peak-hour unidirectional services. This implies the idea that the destination connector from one of Cao's (2013) conclusions enables high frequency services throughout the day. Vuchic (2005) as cited by Hale and Charles (2009) supplemented that the balance between base demand levels and peak demand levels indicate the overall health of a rail network. For practical reasons and based on the afore-mentioned initial results, the concluding remark of van Oort and van Nes (2010) and Ke et al. (2012) suggest that *KTM Komuter* schedule adheres to a with an appropriate signalling system and a recast *KTM Komuter* timetable be implemented to shorten travel time of passengers and to enhance *KTM Komuter's* LOS. The latter is motivated by a cost-effective behaviour-change concerning *KTM Komuter* service operation design and a better passenger distribution. Looking into the appropriate signalling system, its primary pertinent principle is to manage and safeguard every passenger and train without the influences of delays and danger which exist naturally throughout the trips (Ke et al., 2012). In fact, frequency is defined by Hensher et al. (2011) as 'a quadratic of minutes between services, allowing for the marginal disutility to vary by headway'. Their modelling result regarding public transport frequency attribute was very significant, thereby suggesting that an increased frequency would influence the overall travel time of a public transport and its marginal disutility. As such, increased service frequencies also represents more accelerated trains per hour with the effect of frequent stops explicitly (Ke et al., 2012) having a bearing on reduced travel time of the train and simultaneously reducing station stop times between public transport services (Feng, 2011; Toš et al., 2011; Frost et al., 2012; Tsai et al., 2013) which will then lessen its marginal disutility and in turn, increase the probability of one choosing public transport. It is not an easy task to control of a fixed number of station stop times at low level. A reduction in station stop times is often not possible due to many passengers getting on and off crowded trains particularly at associated entrance and exit doors. Gschwender (2007) and Transportation Research Board (2013) highlighted the need for a higher service frequency as an expansion of the service to yield an increase in operational and capital costs due to the much required new drivers, staff and vehicles.

The total survey experience exhibited that the most common time for commuting was the morning rush hour. This implies that the usual start of work time is the most preferred time by the *KTM Komuter* users. In parallel, if the most common time for commuting is the evening peak hour, it is evident that the typical finish working time is the most favoured one. The entire results suggest that passengers frequently assessed quality in *KTM Komuter* operations as a total experience of travelling on it.

As the number of passengers increase, a threshold is reached at which not everyone is able to find a seat and some users need to stand inside vehicles. Subsequently, this will make movement of other passengers more difficult when boarding or alighting a vehicle; therefore, increasing riding time due to friction or crowding effects among passengers. This situation suggests that an average waiting time is not only related to the headway (the inverse of commuter train frequency), but also to the occupancy rate (factor) or crowding levels inside the vehicles in an additive or multiplicative way. It is believed that the occupancy factor of the public transport vehicles in Malaysia is higher than any other developed countries due to the acceptance of greater levels of crowding onboard vehicles in Malaysia.

However, comfort of the onboard vehicles receives much more attention in developed countries than in Malaysia (Gschwender, 2007).

9.3 VEHICLES

R17 =SQRT((G17*D17*F17)/(120*E17))

Maximum Passenger per hour, P_L (KL Inbound)

	Time	Cycle Time,T (minutes)	Co	Cp	P_{L1}	P_{L2}	P_{L3}	P_{L4}	P_{L5}	P_{L6}	P_{L7}	P_{L8}	P_{L9}	P_{L10}	P_{L11}	N_1^*	N_2^*
1	Early Birds (0500 - 0630)	298	662	80	2700	3516										28	32
2	Morning Peak (0630 - 0930)	298	662	80	2941	3253	4441	5075	2700	2496						30	31
3	Late Comers (0930 - 1130)	268	662	80	2494	2660	1448	3431								26	27
4	Afternoon Peak (1130 - 1430)	258	662	80	2789	2597	2393	3467	2484							27	26
5	Early Release (1430 - 1630)	320	662	80	2533	2066	1958	2359								29	26
6	Evening Peak (1630 - 2030)	284	662	80	540	2546	2004	1323	3015	6480	2443	2935	2445	1876	3100	12	27
7	Off Peak (2030 - 2400)	242	662	80	534	270	1185	2500								11	8

Note:
Co = Hourly Cost of TU operation
Cp = Hourly Cost of Passenger Waiting Time
N* = Optimal Fleet Size

Figure 9.7 An Illustrative Calculation of An Optimal Size of Fleet, N_1^* at cell R17 (marked yellow) during the Early Birds for KL Inbound

Table 9.3 Optimum Fleet Sizes for seven time variations for KL Inbound for 2010, N*

Time		Optimum Fleet Sizes for Different Maximum Passenger per hour for KL Inbound for 2010, N*										
		N1*	N2*	N3*	N4*	N5*	N6*	N7*	N8*	N9*	N10*	N11*
1	Early Bird Travellers (0500 - 0630)	28	32									
2	Morning Peak Hours (0630 - 0930)	30	31	37	39	28	27					
3	Late Comers (0930 - 1130)	26	27	20	30							
4	Afternoon Peak Hours (1130 - 1430)	27	26	28	30	25						
5	Early Release (1430 - 1630)	29	26	25	28							
6	Evening Peak Hours (1630 - 2030)	12	27	24	19	29	43	26	29	26	23	30
7	Off Peak Periods (2030 - 2400)	11	8	17	25							

Figure 9.7 shows the calculation of an optimal size of fleet, N_1^* at cell R17 (marked yellow) for the Early Birds for KL Inbound direction. It is calculated using formula (3.3), $N^* = \sqrt{\frac{P_L.T \cdot c_p}{120.c_o}}$. This formula was derived in Chapter 3, under Section 3.6.1(a) on page 110. This figure also shows maximum passenger per trip per hour up to eleven cases subject to data availability from the Passenger Counting Surveys. Cycle time is based on mean journey time obtained from field measurement. Cycle time is one of the physical information that describes the usage

of *KTM Komuter* services. Overall, the optimal values of fleet size in Table 9.3 above range from 8 to 43 for seven time variations based on visual observations. With further reference to Figure 9.8, the technical descriptions are as follows. During peak periods including the morning, afternoon and evening peak periods, the optimal values of fleet size range from 12 to 43. However, the details about the optimal fleet size for morning peak period are from 27 to 39 whereas the details about the optimal fleet size for afternoon peak period are from 25 to 30. The average value of the optimal fleet size for morning peak is 32. The average value of the optimal fleet size for afternoon peak is 27. The evening peak period has eleven readings for the optimal fleet size that range from 12 to 43. The average value of the optimal fleet size for evening peak is 26. During the inter-peak periods, the optimal values of fleet size range from 20 to 30. The inter-peak periods are categorised by periods of late comers and early release. The average value of the optimal fleet size for late comers is 26 whilst the average value of the optimal fleet size for early release is 27. For early birds, there are only two readings recorded for the optimal fleet size and they are 28 and 32. The average value of the optimal fleet size for the early birds is 30. During the off peak period, the optimal values of fleet size range from 8 to 25. The average value of the optimal fleet size for the off peak period is 15. In conclusion, two categories of peak period for KL Inbound i.e. 0630 – 1230 and 1630 – 2130 should be designed with the highest number of fleet size i.e. approximately 28 and 21 respectively. The early bird hours (0500 – 0630), the (1230 – 1630) hours and the remaining off peak hours (2130 – 2400) should be provided with an optimal fleet size roughly of 30, 27 and 15 respectively.

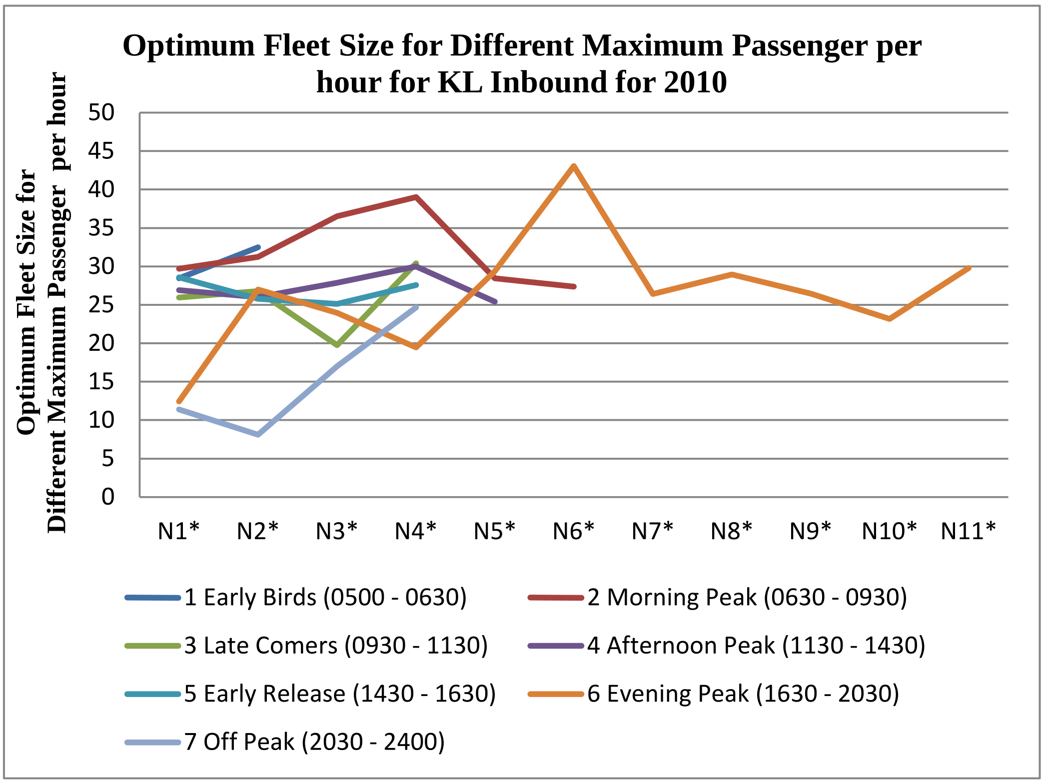


Figure 9.8 Graphical Illustration of Optimum Fleet Sizes, N* for KL Inbound for 2010

P17 =SQRT((G17*D17*F17)/(120*E17))

Maximum Passenger per hour, P_L (KL Outbound)

	Time	Cycle Time,T (minutes)	Co	Cp	P_{L1}	P_{L2}	P_{L3}	P_{L4}	P_{L5}	P_{L6}	P_{L7}	P_{L8}	P_{L9}	N_1*	N_2*
1	Early Birds (0500 - 0630)	278	662	80	1166	2100								18	24
2	Morning Peak (0630 - 0930)	284	662	80	4977	1998	2868	1200	3018	2678				38	24
3	Late Comers (0930 - 1130)	282	662	80	1782	2454	2182	2490						22	26
4	Afternoon Peak (1130 - 1430)	272	662	80	2626	2274	2277	2913	2551	1691				27	25
5	Early Release (1430 - 1630)	284	662	80	2547	3143	4249							27	30
6	Evening Peak (1630 - 2030)	302	662	80	5544	4808	5483	3583	6030	6120	5600	5700	4808	41	38
7	Off Peak (2030 - 2400)	320	662	80	2079	4370	2288	2072	1459					26	38

Note:

Co = Hourly Cost of TU operation

Cp = Hourly Cost of Passenger Waiting Time

N* = Optimal Fleet Size

Figure 9.9 An Illustrative Calculation of An Optimal Size of Fleet, N_1^* at cell P17 (marked yellow) for the Early Birds for KL Outbound

Table 9.4 Optimum Fleet Sizes for seven time variations for KL Outbound for 2010, N*

	Time	**Optimum Fleet Sizes for Different Maximum Passenger per hour for KL Outbound for 2010, N***								
		N_1*	**N_2***	**N_3***	**N_4***	**N_5***	**N_6***	**N_7***	**N_8***	**N_9***
1	Early Bird Travellers (0500 - 0630)	18	24							
2	Morning Peak Hours (0630 - 0930)	38	24	29	19	29	28			
3	Late Comers (0930 - 1130)	22	26	25	27					
4	Afternoon Peak Hours (1130 - 1430)	27	25	25	28	26	22			
5	Early Release (1430 - 1630)	27	30	35						
6	Evening Peak Hours (1630 - 2030)	41	38	41	33	43	43	41	42	38
7	Off Peak Periods (2030 - 2400)	26	38	27	26	22				

Figure 9.9 shows the calculation of an optimal size of fleet, N_1^* at cell P17 (marked yellow) for the Early Birds for KL Outbound direction. It is calculated using formula (3.3), $N^* = \sqrt{\frac{P_L . T \cdot c_p}{120 . c_o}}$. This formula was derived in Chapter 3, under Section 3.6.1 (a) on page 110. This figure also shows different maximum passenger per trip per hour up to nine cases subject to data availability from the Passenger Counting Surveys and cycle time is based on mean journey time obtained from field measurement. Overall, Table 9.4 depicts the optimal values of fleet size that range from 18 to 43 for seven time variations based on visual observations. The following technical descriptions are referred to in Figure 9.10. During the peak

periods including the morning, afternoon and evening peak periods, the optimal values of fleet size vary from 19 to 43. However, the details of the optimal fleet size for morning peak period ranges from 19 to 38 whereas the details for the optimal fleet size for the afternoon peak period ranges from 22 to 28. The average value of the optimal fleet size for morning peak is 28. The average value of the optimal fleet size for the afternoon peak period is 26. The evening peak period has nine readings for the optimal fleet size that range from 33 to 43. The average value of the optimal fleet size for the evening peak period is 40. During the inter-peak periods, the optimal values of fleet size range from 22 to 35. The inter-peak periods are categorised by the periods for the late comers and early release. The average value of the optimal fleet size for late comers is 25 whilst the average value of the optimal fleet size for early release is 31. During the early bird travel mode, there are only two readings recorded for the optimal fleet size that are 18 and 24. The average value of the optimal fleet size for the early bird is 21. During off peak period, the optimal values of fleet size range from 22 to 38. The average value of the optimal fleet size for the off peak period is 28. In conclusion, three categories of peak period for KL Outbound were noted namely i.e. 0630 – 0930, 1000 - 1300 and 1600 – 2100 and these should be designed with the highest number of fleet size i.e. approximately 28, 26 and 33 respectively. The early bird hours (0500 – 0630), the (1300 – 1600) hours and the remaining off peak hours (2100 – 2400) should be provided with an optimal fleet size roughly of 21, 28 and 28 respectively.

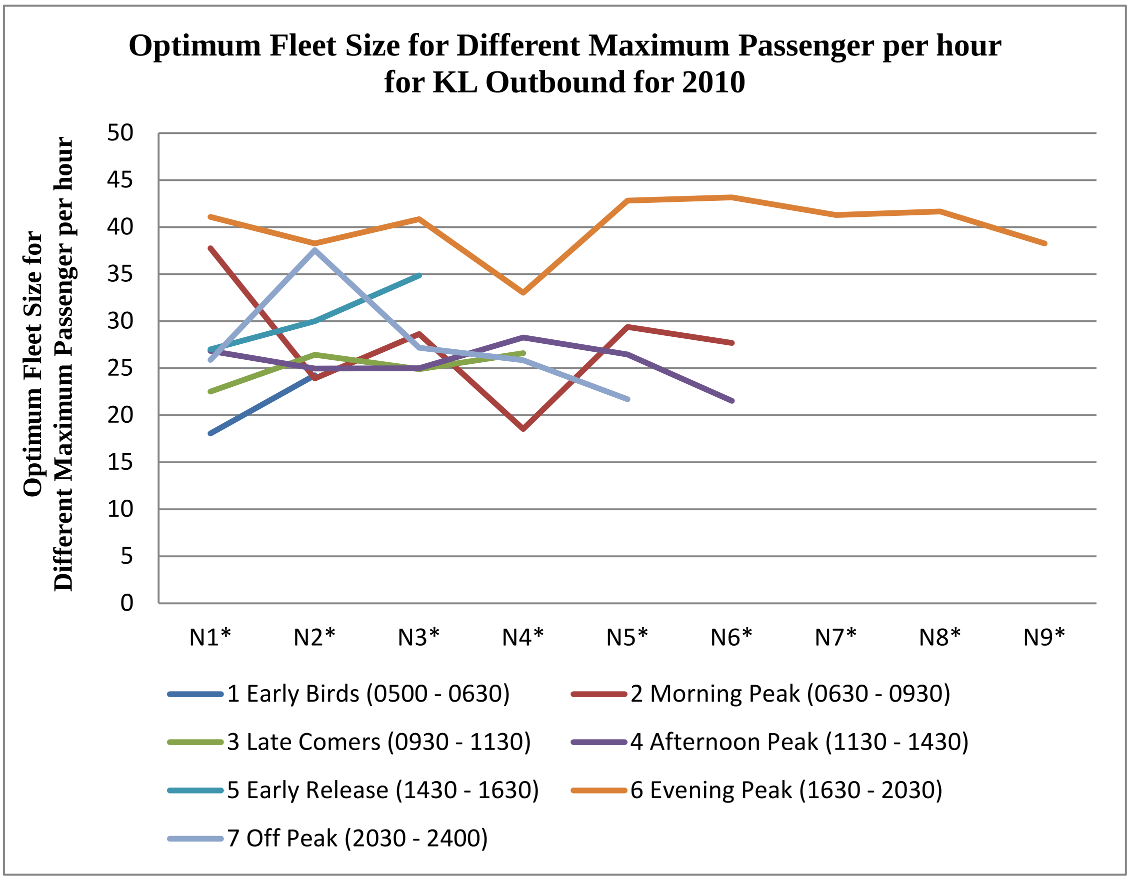


Figure 9.10 Graphical Illustration of Optimum Fleet Sizes, N* for KL Outbound for 2010

AP17 | f_x | =((G17*54*E17)/(AC17*F17))^0.5*(2*AN17/AO17)

Maximum Passenger per hour, P_L (KL Inbound)

Time	Co	Cp	P_{L1}	P_{L2}	P_{L3}	P_{L4}	P_{L5}	P_{L6}	P_{L7}	P_{L8}	P_{L9}	P_{L10}	P_{L11}	N_1^*	N_2^*	N_3^*	N_4^*	N_5^*	N_6^*	N_7^*	N_8^*	N_9^*	N_{10}^*	N_{11}^*	v_{c1}	v_{c2}	v_{c3}	v_{c4}	v_{c5}	v_{c6}	v_{c7}	v_{c8}	v_{c9}	v_{c10}	v_{c11}	Ratio of passenger volume on Maximum Load Section (MLS) to the volume	Maximum load factor-capacity utilization coefficient, α_{max}	C_{TU1}^*	C_{TU2}^*
	2010																																						
1 Early Birds (0500 - 0630)	662	80	2700	3516										28	32										22.9	20.1										0.288	0.5	264	322
2 Morning Peak (0630 - 0930)	662	80	2941	3253	4441	5075	2700	2496						30	31	37	39	28	27						22.0	20.9	17.9	16.7	22.9	23.8						0.150	0.5	147	158
3 Late Comers (0930 - 1130)	662	80	2494	2660	1448	3431								26	27	20	30								28.0	27.1	36.7	23.8								0.168	0.5	134	141
4 Afternoon Peak (1130 - 1430)	662	80	2789	2597	2993	3467	2484							27	26	28	30	25							28.0	29.0	27.0	25.1	29.7							0.214	0.5	181	171
5 Early Release (1430 - 1630)	662	80	2533	2066	1958	2359								29	26	25	28								21.3	23.5	24.2	22.0								0.224	0.5	207	177
6 Evening Peak (1630 - 2030)	662	80	540	2546	2004	1323	3015	6480	2443	2935	2445	1876	3100	12	27	24	19	29	43	26	29	26	23	30	55.1	25.4	28.6	35.2	23.3	15.9	25.9	23.6	25.9	29.5	23.0	0.147	0.5	39	125
7 Off Peak (2030 - 2400)	662	80	534	270	1185	2500								11	8	17	25								70.4	39.0	47.3	32.5								0.226	0.5	53	32

Note:

Co = Hourly Cost of TU operation

Cp = Hourly Cost of Passenger Waiting Time

N* = Optimal Fleet Size

v_c = Cycle Speed

C_{TU}^* = Optimal Vehicle Type or TU Capacity

Figure 9.11 An Illustrative Calculation of An Optimal TU or Vehicle Capacity, C_{TU1}^* at cell AP17 (marked yellow) for the Early Birds for KL Inbound

Table 9.5 Optimal Transit Unit or Vehicle Capacities, CTU*

for KL Inbound for 2010

	Time	Optimal Transit Unit or Vehicle Capacities, CTU* for Different Maximum Passenger per hour for KL Inbound for 2010										
		C_{TU1}*	C_{TU2}*	C_{TU3}*	C_{TU4}*	C_{TU5}*	C_{TU6}*	C_{TU7}*	C_{TU8}*	C_{TU9}*	C_{TU10}*	C_{TU11}*
1	Early Bird Travellers	264	322									
2	Morning Peak Hours	147	158	200	221	138	130					
3	Late Comers	134	141	89	170							
4	Afternoon Peak Hours	181	171	190	213	166						
5	Early Release	207	177	170	196							
6	Evening Peak Hours	39	125	104	76	141	251	121	139	121	99	144
7	Off Peak Periods	53	32	96	167							

Figure 9.11 illustrates the calculation of an optimal TU or Vehicle Capacity, C_{TU1}^{*} at cell AP17 (marked yellow) for the Early Birds for KL Inbound direction. It is calculated using formula (3.4), $C_{TU}^{*} = \frac{2\eta_p}{\alpha_{\max}}\sqrt{\frac{P_L L c_o}{v_c c_p}}$ applying a maximum passenger per trip per hour which is obtained from Passenger Boarding-OnBoard-Alighting Counting Surveys and includes commuter train cycle speed, ratio of

passenger volume on Maximum Load Section (MLS) to the volume on the entire line, η_p and maximum load factor-capacity utilization coefficient, α_{max} of all which were obtained from field measurements. This formula was derived in Chapter 3, under Section 3.6.2 on page 114. Overall, the optimal values of Vehicle Type or Transit Unit, TU Capacity in Table 9.5 range from 32 to 322 for seven time variations based on the visual observations. Figure 9.12 shows that during peak periods including the morning, afternoon and evening peak periods, the optimal values of TU Capacity range from 39 to 251. However, the details for the optimal TU Capacity for morning peak period differs from 130 to 221 whereas the details for the optimal TU Capacity for afternoon peak period ranges from 166 to 213. The average value of the optimal TU Capacity for morning peak period is 166. The average value of the optimal TU Capacity for afternoon peak period is 184. The evening peak period has eleven readings for the optimal TU Capacity that range from 39 to 251. The average value of the optimal TU Capacity for evening peak period is 124. During the inter-peak periods, the optimal values of TU Capacity are from 89 to 207. The inter-peak periods are categorised by periods of late comers and early release. The average value of the optimal TU Capacity for late comers is 134 whilst the average value of the optimal TU Capacity for early release is 188. For early birds, there are only two readings recorded for the optimal TU Capacity and they are 264 and 322. The average value of the optimal TU Capacity for the early birds is 293. During the off peak period, the optimal values of TU Capacity range from 32 to 167. The average value of the optimal TU Capacity for the off peak period is 87. In conclusion, two categories of peak period for KL Inbound i.e. 0630 – 1230 and 1630 – 2130 should be designed with the highest number of TU Capacity i.e. approximately 161 and 106 respectively.

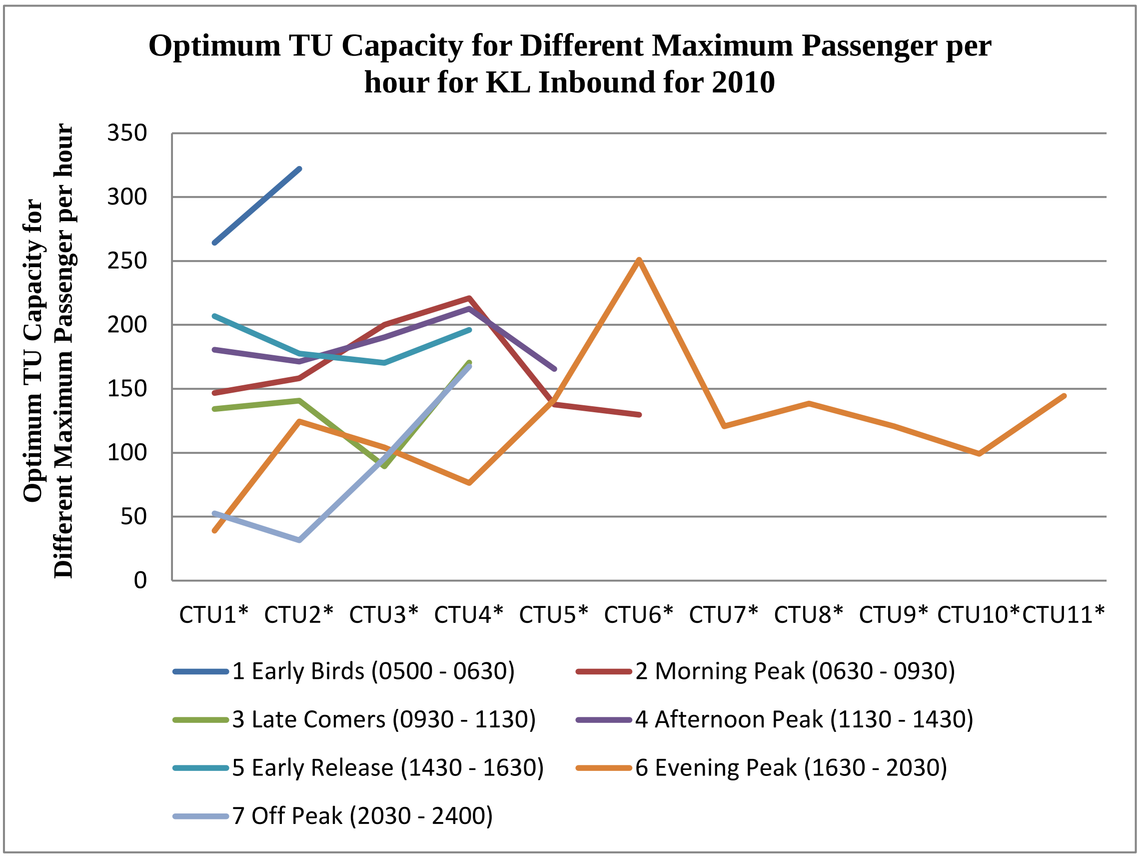


Figure 9.12 Graphical Illustration of Optimal Transit Unit or Vehicle Capacities, CTU* for KL Inbound for 2010

AJ17 | f_x | =((G17*54*E17)/(Y17*F17))^0.5*(2*AH17/AI17)

Maximum Passenger per hour, P_L (KL Outbound)

2010

	Time	Co	Cp	P_{L1}	P_{L2}	P_{L3}	P_{L4}	P_{L5}	P_{L6}	P_{L7}	P_{L8}	P_{L9}
1	Early Birds (0500 - 0630)	662	80	1166	2100							
2	Morning Peak (0630 - 0930)	662	80	4977	1998	2868	1200	3018	2678			
3	Late Comers (0930 - 1130)	662	80	1782	2454	2182	2490					
4	Afternoon Peak (1130 - 1430)	662	80	2626	2274	2277	2913	2551	1691			
5	Early Release (1430 - 1630)	662	80	2547	3143	4249						
6	Evening Peak (1630 - 2030)	662	80	5544	4808	5483	3583	6030	6120	5600	5700	4808
7	Off Peak (2030 - 2400)	662	80	2079	4370	2288	2072	1459				

	Time	N_1^*	N_2^*	N_3^*	N_4^*	N_5^*	N_6^*	N_7^*	N_8^*	N_9^*
1	Early Birds (0500 - 0630)	18	24							
2	Morning Peak (0630 - 0930)	38	24	29	19	29	28			
3	Late Comers (0930 - 1130)	22	26	25	27					
4	Afternoon Peak (1130 - 1430)	27	25	25	28	26	22			
5	Early Release (1430 - 1630)	27	30	35						
6	Evening Peak (1630 - 2030)	41	38	41	33	43	43	41	42	38
7	Off Peak (2030 - 2400)	26	38	27	26	22				

	Time	v_{c1}	v_{c2}	v_{c3}	v_{c4}	v_{c5}	v_{c6}	v_{c7}	v_{c8}	v_{c9}	Ratio of passenger volume on Maximum Load Section (MLS) to the volume on the entire line, η_p	Maximum load factor-capacity utilization coefficient, α_{max} (passengers/space)	C_{TU1}^*	C_{TU2}^*
1	Early Birds (0500 - 0630)	38.71	29								0.236	0.5	109	170
2	Morning Peak (0630 - 0930)	18.14	29	24	36.9	23.3	24.7				0.231	0.5	324	163
3	Late Comers (0930 - 1130)	30.64	26	28	25.9						0.223	0.5	144	183
4	Afternoon Peak (1130 - 1430)	26.65	29	29	25.3	27.0	33.2				0.216	0.5	181	163
5	Early Release (1430 - 1630)	25.36	23	20							0.221	0.5	187	219
6	Evening Peak (1630 - 2030)	15.68	17	16	19.5	15.0	14.9	15.6	15.5	16.8	0.174	0.5	277	249
7	Off Peak (2030 - 2400)	23.47	16	22	23.5	28.0					0.286	0.5	228	397

Note:

Co = Hourly Cost of TU operation

Cp = Hourly Cost of Passenger Waiting Time

N^* = Optimal Fleet Size

v_c = Cycle Speed

C_{TU}^* = Optimal Vehicle Type or TU Capacity

Figure 9.13 An Illustrative Calculation of An Optimal TU or Vehicle Capacity, C_{TU1}^* at cell AJ17 (marked yellow) for the Early Birds for KL Outbound

Table 9.6 Optimal Transit Unit or Vehicle Capacities, $C_{TU}*$
for KL Outbound for 2010

Time		Optimal TU or Vehicle Capacities for Different Maximum Passenger per hour for KL Outbound for 2010								
		CTU1*	**CTU2***	**CTU3***	**CTU4***	**CTU5***	**CTU6***	**CTU7***	**CTU8***	**CTU9***
1	Early Bird Travellers (0500 - 0630)	109	170							
2	Morning Peak Hours (0630 - 0930)	324	163	214	111	222	203			
3	Late Comers (0930 - 1130)	144	183	167	185					
4	Afternoon Peak Hours (1130 - 1430)	181	163	163	196	177	130			
5	Early Release (1430 - 1630)	187	219	275						
6	Evening Peak Hours (1630 - 2030)	277	249	274	199	295	298	279	282	249
7	Off Peak Periods (2030 - 2400)	228	397	245	227	175				

Figure 9.13 illustrates the calculation of an optimal TU or Vehicle Capacity, C_{TU1}^{*} at cell AJ17 (marked yellow) for the Early Birds for KL Outbound direction. It is calculated using formula (3.4), $C_{TU}^{*} = \frac{2\eta_p}{\alpha_{\max}}\sqrt{\frac{P_L L c_o}{v_c c_p}}$ applying a maximum passenger per trip per hour which is obtained from Passenger Boarding-OnBoard-Alighting Counting Surveys and includes commuter train cycle speed, ratio of passenger volume on MLS to the volume on the entire line, η_p and maximum load factor-capacity utilization coefficient, α_{max} which were all obtained from field measurements. This formula was derived in Chapter 3, under Section 3.6.2 on page 114. Overall, the optimal values of Vehicle Type or Transit Unit, TU Capacity in

Table 9.6 range from 109 to 397 for seven time variations based on visual observations. Figure 9.14 displays the technical descriptions as follows: During peak periods including the morning, afternoon and evening peak periods, the optimal values of TU Capacity range from 111 to 324. However, the details of the optimal TU Capacity for morning peak period range from 111 to 324 whereas the details of the optimal TU Capacity for afternoon peak period vary from 130 to 196. The average value of the optimal TU Capacity for morning peak period is 206. The average value of the optimal TU Capacity for afternoon peak period is 168. The evening peak period has nine readings for the optimal TU Capacity that range from 199 to 298. The average value of the optimal TU Capacity for evening peak period is 267. During the inter-peak periods, the optimal values of TU Capacity range from 144 to 275. The inter-peak periods are categorised by the periods of late comers and early release. The average value of the optimal TU Capacity for late comers is 170 whilst the average value of the optimal TU Capacity for early release is 227. During the early bird travelling mode, there were only two readings recorded for the optimal TU Capacity namely 109 and 170. The average value of the optimal TU Capacity for early birds is 140. During the off peak period, the optimal values of TU Capacity vary from 175 to 397. The average value of the optimal TU Capacity for the off peak period stands at 254. In conclusion, three categories of peak period for KL Outbound were noted namely i.e. 0630 – 0930, 1000 - 1300 and 1600 – 2100 and these should be designed with the highest number of TU Capacity i.e. approximately 206, 169 and 249 respectively.

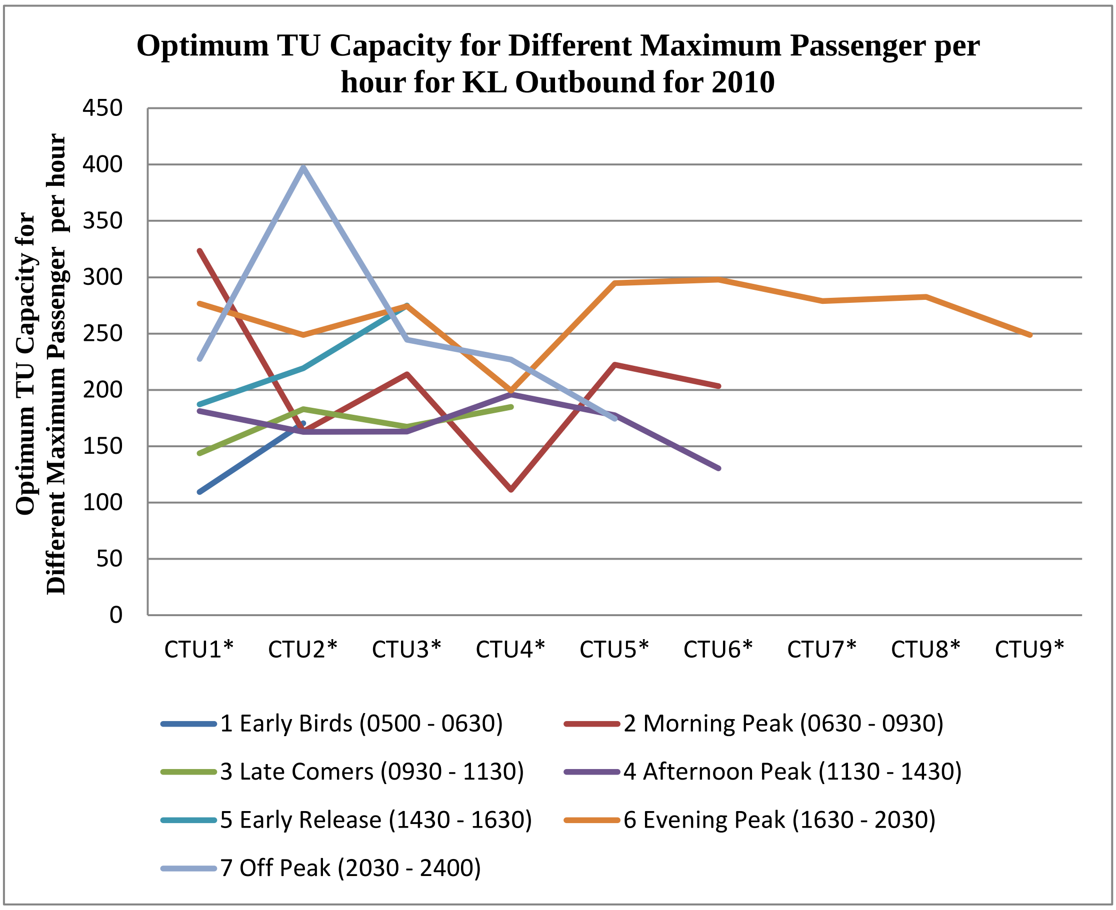


Figure 9.14 Graphical Illustration of Optimal Transit Unit or Vehicle Capacities, CTU* for KL Outbound for 2010

In addition to better closer service headways, more efficient timetables (journey making) and passengers' comfort at platforms, at stations and on board trains as well as desirable dwell times at every station that have been mentioned under Section 9.1, other methods as part of capacity, speed and reliability improvements could optimise use of existing rolling stock (fleets) within the capacity available (Hine and Grieco, 2003; Kamba et al., 2007; Transportation Research Board, 2013) by rearranging it and the associated capacity provided on operations; notwithstanding, including the lengthening trains as empirical evidence by Syahriah et al.'s (2013) research and platforms. However, most of the EMU are reaching their end of lifecycle and thus, frequently being repaired. The scope of capacity improvements is together with improving accessibility (Preston and Rajé, 2007) and connectivity as expected by the GTP 1.0 Improving Urban Public Transport (Buehler and Pucher, 2011; Performance Management & Delivery Unit, 2011, accessed on July 9, 2014). All these except for the last option are short-term options with cheaper operational modifications which will maximize existing resources. This lengthening of train at *KTM Komuter* requires either additional infrastructure and/or changes to the existing infrastructure in which this method of capacity improvement can consider coach adjustment to increase seating provision or cause one to consider the removal of seats to provide standing spaces within the availability of train capacity. Such method is recommended based on the experience of British railways as published in Frost et al. (2012). In short, Hale and Charles (2009) confirmed that passenger rail systems were commonly equipped with new infrastructure, rolling stock and provision of services to operationalise peak demand. As such, these capacity improvements and maintenance programmes support the facts of Syahriah et al. (2008; 2013) that excessive capacity but reduction of feeder services and lack of maintenance deteriorate the quality of public transport service especially during peak hours in most developing countries. While longer platforms are constrained by land acquisition for construction reserve sites, one must not forget to upgrade communication systems and the construction/repositioning of power services which are also required to cope with the growing power of electricity. In conclusion, the optimal operating environment and service pattern of one service will determine its capacity and the quality of service in accordance with the Transportation Research Board (2013).

9.4 FARES

Figure 9.15 illustrates the calculation of an optimal price, P_1^* at cell U17 (marked yellow) for the Early Birds for KL Inbound direction. It is calculated using formula (3.5), $P^* = m\left(\frac{C_2}{L} + \frac{V_2}{M} t_2 P\right)$ applying a maximum passenger per trip per hour, mean passenger trip length and mean boarding time per passenger which are obtained from the Passenger Counting Survey and several parameters obtained from field measurements. This formula was derived in Chapter 3, under Section 3.6.2 on page 118. Overall, the optimal values of Price in Table 9.7 range from RM0.08 to RM0.51 for seven time variations based on visual observations. With further reference to Figure 9.16, the important descriptions are as follows. During the morning, afternoon and evening peak periods, the optimal values of Price range from 8 cents to 51 cents.

U17 =(D17*E17/T17)+(D17*F17*G17*I17/H17)

Maximum Passenger per hour, P_L (KL Inbound)

Row	B	Time	Mean Passenger Trip Length, m (km)	Mean Operating Cost per Passenger-km, C_2 (RM)	Mean value of in-vehicle time, V_2 (cents/minute)	Mean Boarding Time per passenger, t (minute/passenger)	Train Kilometres per route per hour, M	P_{L1}	P_{L2}	P_{L3}	P_{L4}	P_{L5}	P_{L6}	P_{L7}	P_{L8}	P_{L9}	P_{L10}	P_{L11}	Maximum load factor-capacity utilization coefficient, α_{max} (passengers/space)	P_1^*	P_2^*
15			2010																		
17	1	Early Birds (0500 - 0630)	28.3	0.17	0.36	0.091	108.0	2700	3516										0.5	33	40
18	2	Morning Peak (0630 - 0930)	24.6	0.06	0.36	0.091	108.0	2941	3253	4441	5075	2700	2496						0.5	25	27
19	3	Late Comers (0930 - 1130)	22.9	0.19	0.36	0.091	81.0	2494	2660	1448	3431								0.5	32	33
20	4	Afternoon Peak (1130 - 1430)	22.6	0.11	0.36	0.091	90.0	2789	2597	2993	3467	2484							0.5	28	26
21	5	Early Release (1430 - 1630)	20.5	0.20	0.36	0.091	81.0	2533	2066	1958	2359								0.5	29	25
22	6	Evening Peak (1630 - 2030)	24.2	0.08	0.36	0.091	108.0	540	2546	2004	1323	3015	6480	2443	2935	2445	1876	3100	0.5	8	23
23	7	Off Peak (2030 - 2400)	20.9	0.37	0.36	0.091	123.4	534	270	1185	2500								0.5	18	17

Figure 9.15 An Illustrative Calculation of Optimal Price, P_1^* at cell U17 (marked yellow) for the Early Birds for KL Inbound

However, the details about the optimal Price for morning peak period ranges from RM0.22 to RM0.41 whereas the details on the optimal Price for afternoon peak period are between 25 cents and 33 cents. The average value of the optimal Price for morning peak period is RM0.29. The average value of the optimal Price for afternoon peak period is RM0.28. The evening peak period has eleven readings for the optimal Price that range from RM0.08 to RM0.51. The average value of the optimal Price for evening peak period is 23 cents. During inter-peak periods, the optimal values of Price range from RM0.22 to RM0.40. The inter-peak periods are categorised by periods of late comers and early release. The average value of the optimal Price for late comers is 32 cents whilst the average value of the optimal Price for early release is 27 cents. During the early bird period, there are only two readings recorded for the optimal Price at 33 cents and 40 cents. The average value of the optimal Price for the early bird period is 37 cents. During the off peak period, the optimal values of Price range from 17 cents to 29 cents. The average value of the optimal Price for off peak period is 22 cents. Therefore, it can be deduced that two categories of peak period for KL Inbound i.e. 0630 – 1230 and 1630 – 2130 should be designed at the highest Price at approximately RM0.30 and RM0.23 respectively.

Table 9.7 Optimal Prices, P* for seven time variations for KL Inbound for 2010

Time		**Optimal Prices, P* for Different Maximum Passenger per hour for KL Inbound for 2010**										
		P_1*	**P_2***	**P_3***	**P_4***	**P_5***	**P_6***	**P_7***	**P_8***	**P_9***	**P_{10}***	**P_{11}***
1	Early Bird Travellers (0500 - 0630)	33	40									
2	Morning Peak Hours (0630 - 0930)	25	27	36	41	23	22					
3	Late Comers (0930 - 1130)	32	33	22	40							
4	Afternoon Peak Hours (1130 - 1430)	28	26	30	33	25						
5	Early Release (1430 - 1630)	29	25	24	28							
6	Evening Peak Hours (1630 - 2030)	8	23	19	14	26	51	22	25	22	18	27
7	Off Peak Periods (2030 - 2400)	18	17	22	29							

There are two examples of data regarding total (optimal) prices for one day where the amounts are clearly found to be less than RM2.00 per day. Meanwhile, the average value of the total optimal price is reported to be RM1.83. Another two cases depict values of total (optimal) prices of less than RM2.00 per day too. This average value of the total optimal price is found to be slightly lower than the yields or average fares per boarding from 2008 to 2013 ranging from RM2.11 in 2008 to RM1.90 in 2011 to RM2.20 to RM2.40 in 2013. Moreover, other cases unfortunately indicate insufficient technical data to strongly support the above-mentioned data in the statements in this paragraph.

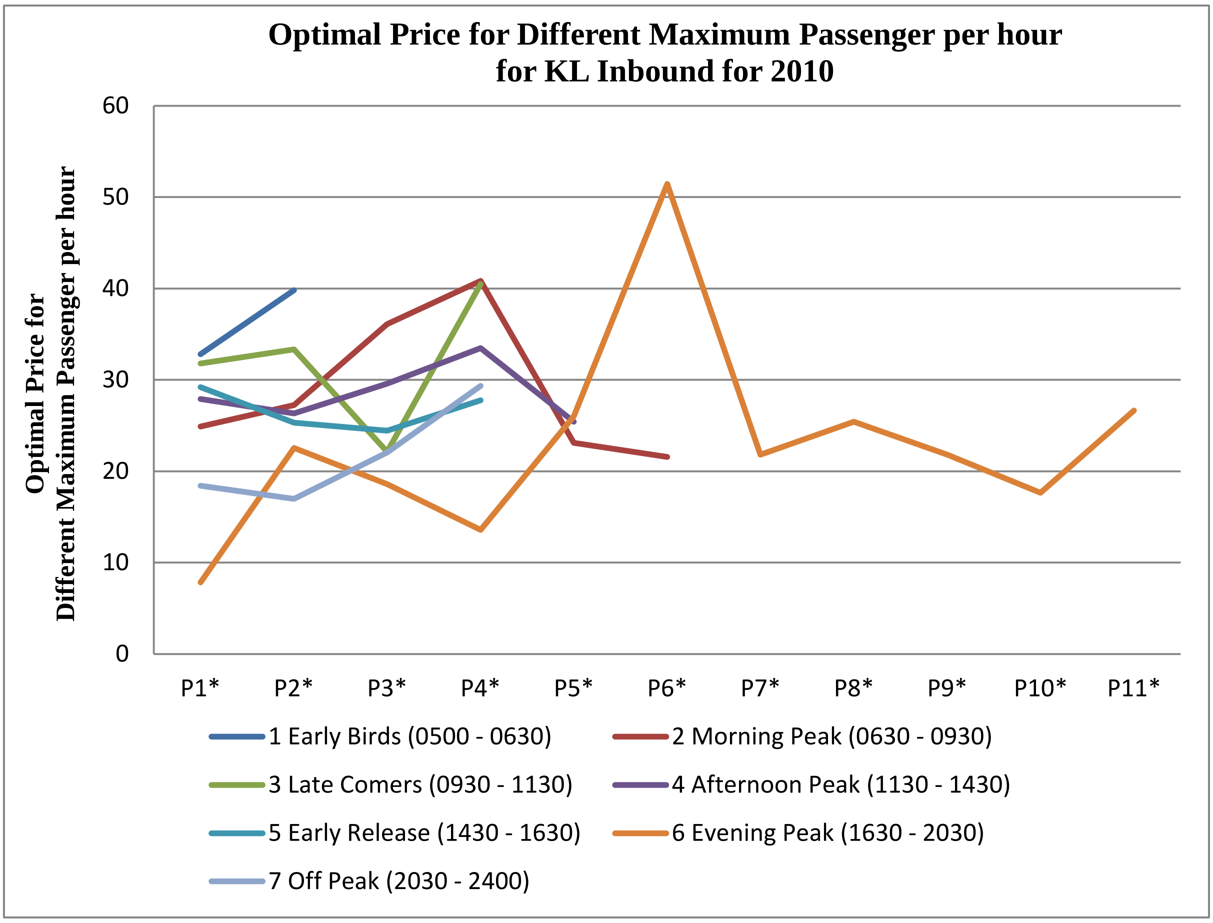


Figure 9.16 Graphical Illustration of Optimal Prices, P* for seven time variations for KL Inbound for 2010

S17 f_x =(D17*E17/R17)+(D17*F17*G17*I17/H17)

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
14	Maximum Passenger per hour, P_L (KL Outbound)																		
15		Time	2010																
16			Mean Passenger Trip Length, m (km)	Mean Operating Cost per Passenger-km, C_2 (RM)	Mean value of in-vehicle time, V_2 (cents/minute)	Mean Boarding Time per passenger, t_2 (minute/passenger)	Train Kilometres per route per hour, M	P_{L1}	P_{L2}	P_{L3}	P_{L4}	P_{L5}	P_{L6}	P_{L7}	P_{L8}	P_{L9}	Maximum load factor-capacity utilization coefficient, α_{max} (passengers/space)	P_1*	P_2*
17	1	Early Birds (0500 - 0630)	15.9	0.56	0.36	0.091	108.0	1166	2100								0.5	23	28
18	2	Morning Peak (0630 - 0930)	22.2	0.10	0.36	0.091	126.0	4977	1998	2868	1200	3018	2678				0.5	33	16
19	3	Late Comers (0930 - 1130)	23.1	0.12	0.36	0.091	162.0	1782	2454	2182	2490						0.5	14	17
20	4	Afternoon Peak (1130 - 1430)	20.8	0.11	0.36	0.091	108.0	2626	2274	2277	2913	2551	1691				0.5	21	19
21	5	Early Release (1430 - 1630)	23.6	0.08	0.36	0.091	135.0	2547	3143	4249							0.5	19	22
22	6	Evening Peak (1630 - 2030)	23.7	0.03	0.36	0.091	121.5	5544	4808	5483	3583	6030	6120	5600	5700	4808	0.5	37	32
23	7	Off Peak (2030 - 2400)	20.7	0.14	0.36	0.091	92.6	2079	4370	2288	2072	1459					0.5	21	38

Figure 9.17 An Illustrative Calculation of An Optimal Price, P_1^* at cell S17 (marked yellow) during the Early Birds for KL Outbound

Table 9.8 Optimal Prices, P* for seven time variations for KL Outbound for 2010

Time		Optimal Prices, P* for Different Maximum Passenger per hour for KL Outbound for 2010								
		P_1*	**P_2***	**P_3***	**P_4***	**P_5***	**P_6***	**P_7***	**P_8***	**P_9***
1	Early Bird Travellers (0500 - 0630)	23	28							
2	Morning Peak Hours (0630 - 0930)	33	16	21	11	22	20			
3	Late Comers (0930 - 1130)	14	17	16	17					
4	Afternoon Peak Hours (1130 - 1430)	21	19	19	23	21	15			
5	Early Release (1430 - 1630)	19	22	28						
6	Evening Peak Hours (1630 - 2030)	37	32	36	24	40	41	37	38	32
7	Off Peak Periods (2030 - 2400)	21	38	22	21	16				

Figure 9.17 illustrates the calculation of an optimal price, P_1^* at cell S17 (marked yellow) for the Early Birds for KL Outbound direction. Similar to Figure 9.15, it is calculated using formula (3.5), $P^* = m\left(\frac{c_2}{L} + \frac{v_2}{M} t_2 P\right)$ applying a maximum passenger per trip per hour, mean passenger trip length and mean boarding time per passenger which are obtained from the Passenger Counting Survey and that from site measurements. This formula was derived in Chapter 3, under Section 3.6.2 on page 118. Overall, the optimal values of Price in Table 9.8 range from RM0.11 to RM0.41 for seven time variations based on visual observations. The following describe Figure 9.18. During the morning, afternoon and evening peak periods, the optimal values of Price range from 11 cents to 41 cents. However, the details about the optimal Price for morning peak period range from RM0.11 to RM0.33 whereas the optimal Price for afternoon peak period ranges from 15 cents to 23 cents. The average value of the optimal Price for morning peak period is RM0.21. The average value of the optimal Price for afternoon peak period is RM0.20. The evening peak period has nine readings for the optimal Price that range from RM0.24 to RM0.41. The average value of the optimal Price for evening peak period is 35 cents. During the inter-peak periods, the optimal values of Price differ from RM0.14 to RM0.28. The inter-peak periods are categorised by the periods of late comers and early release. The average value of the optimal Price for late comers is 16 cents whilst the average value of the optimal Price for early release is 23 cents. For early birds, there are only two readings recorded for the optimal Price and they are 23 cents and 28 cents. The average value of the optimal Price for the early birds is 26 cents. During off peak period, the optimal values of Price range from 16 cents to 38 cents. The average value of the optimal Price for off peak period is 24 cents. Therefore, it can be deduced that three categories of peak period for KL Outbound namely 0630 – 0930, 1000 - 1300 and 1600 – 2100 should be designed at the highest Price at approximately RM0.21, RM0.18 and RM0.27 respectively.

There are two examples of data regarding total (optimal) prices for one day of which their amounts have an average optimal price that is RM1.70 per day. So, the most obvious finding to emerge from this optimisation model of the KL Outbound is that the total optimal price is less than RM2.00 per day. Another case showcases value of total (optimal) price of less than RM1.45 per day. This average value of the total optimal price is comparatively lower than the yields or average fares per boarding from 2008 to 2013 that range from RM2.11 in 2008 to RM1.90 in 2011 to RM2.20 to RM2.40 in 2013. It is disappointing to note that in other cases there is indication of insufficient technical data to strongly support the above-mentioned data in the statements in this paragraph.

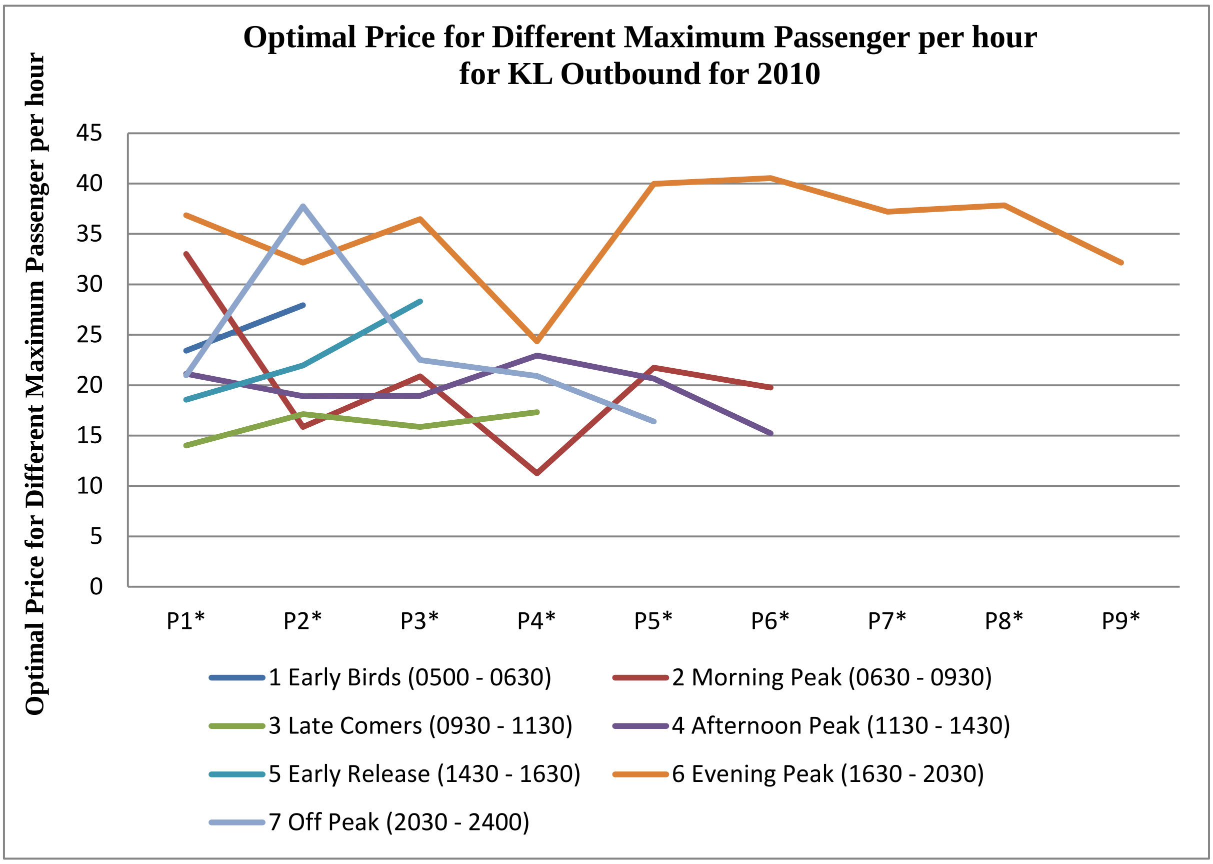


Figure 9.18 Illustrative Presentation of Optimal Prices, P* for seven time variations for KL Outbound for 2010

There will be no more fare reduction in future as the existing fares are quite cheap by line and station, accounting for an operating cost per day per passenger-km of RM0.108 since 2003. Maintaining cheaper fares have boosted travel demand of other travel periods other than the peaks and would be expected to maintain the increasing demand consistently. The calculation of *KTM Komuter* fares is based on distance travelled between the rail stations with no consideration on subsidy. The derivation of a practical *KTM Komuter* Timetable can be done by altering fares or frequencies to investigate the effects of changing *KTM Komuter's* operations. As a preliminary to designing the timetable, it is necessary to work out the changes in resources used i.e. the supply changes and link of train sets to operate the revised services. This step involves schedules being drawn up manually using Microsoft Excel to estimate the number of EMU sets of stock needed prior to designing both a working timetable and a public timetable using the ROMAN-D and ROMAN-P computer software respectively.

ROMAN stands for Route Management System which originated from Austria. The ROMAN System is useful because it assists the Operation Manager in managing the capacity of rail track by planning and designing the timetable of the *KTM Komuter* or by simply managing and controlling the operations of *KTM Komuter*. This ROMAN System was upgraded from a small scale Computer Add Railway Scheduling (CARAS) System to a system with standard database called ROMAN-Database (ROMAN-DB) at Sun Server and it had five modules in 2002. The CARAS System downloads data to Crew Planning Scheduling (CPS), Centralised Train Controller (CTC) and Passenger Information System (PIS). The five modules are ROMAN-Planning (ROMAN-D), ROMAN-Public (ROMAN-P), ROMAN-Calculation (ROMAN-C), ROMAN-Simulation (ROMAN-S) and ROMAN-Connect (ROMAN-I). Other main features of ROMAN include infrastructure management, run-time calculation, timetable planning, timetable simulation reports, system and user administration, export interfaces, output reports and product, and modern interactive graphical user interface. Only two packages are explained subsequently because each of these packages can be run on its own. The ROMAN-D is a ROMAN-Planning module using Roman-D version 4.4.11. This module is used for strategic, calendar based and short term timetable planning. It supports parallel group work and data exchange for note-book operation. It also shows the geographic display of the railway net with various searching features. The ROMAN-P is a ROMAN-Public module. This module generates various public timetable printouts. These include national and international timetables, timetable folders, arrival/departure timetables and posters.

To design a working timetable on arrival/departure and to plot a corresponding train graph using the following Actual Service Frequencies of *KTM Komuter* (i.e. the three KOMI commuter train models), results in adequate services for the public but it is so complex that it may require detailed analyses and decisions. These Actual Service Frequencies should be designed as Design Service Frequencies as shown below to be more realistic in terms of planning and operations. The control of train supply and demand and being economically efficient cater to the increasing number of passengers such as overcrowding at both platforms and onboard trains. The Design Service Frequencies designated, notably demonstrated high-frequency services such that high-frequency services were justified by demand on all lines. Thus, computational analysis on real data set in 2010 applying these Actual Service Frequencies using the ROMAN-D yielded a viable solution of Design Service Frequencies within rational computing service headways i.e. 10 and 15 minutes only for both KL Inbound and KL Outbound directions as well as high utilization of tracks at the same time. The rescheduling process involving train and crew scheduling can be done manually by experienced technical (operation) *KTMB* staff when a schedule is disrupted. The arrival/departure working timetable printouts are also sent to the Centralised Train Controller (CTC) so that the ILTIS in this CTC can assist in operating the *KTM Komuter* systems. ILTIS is the German abbreviation for Integrated Traffic Information System in English.

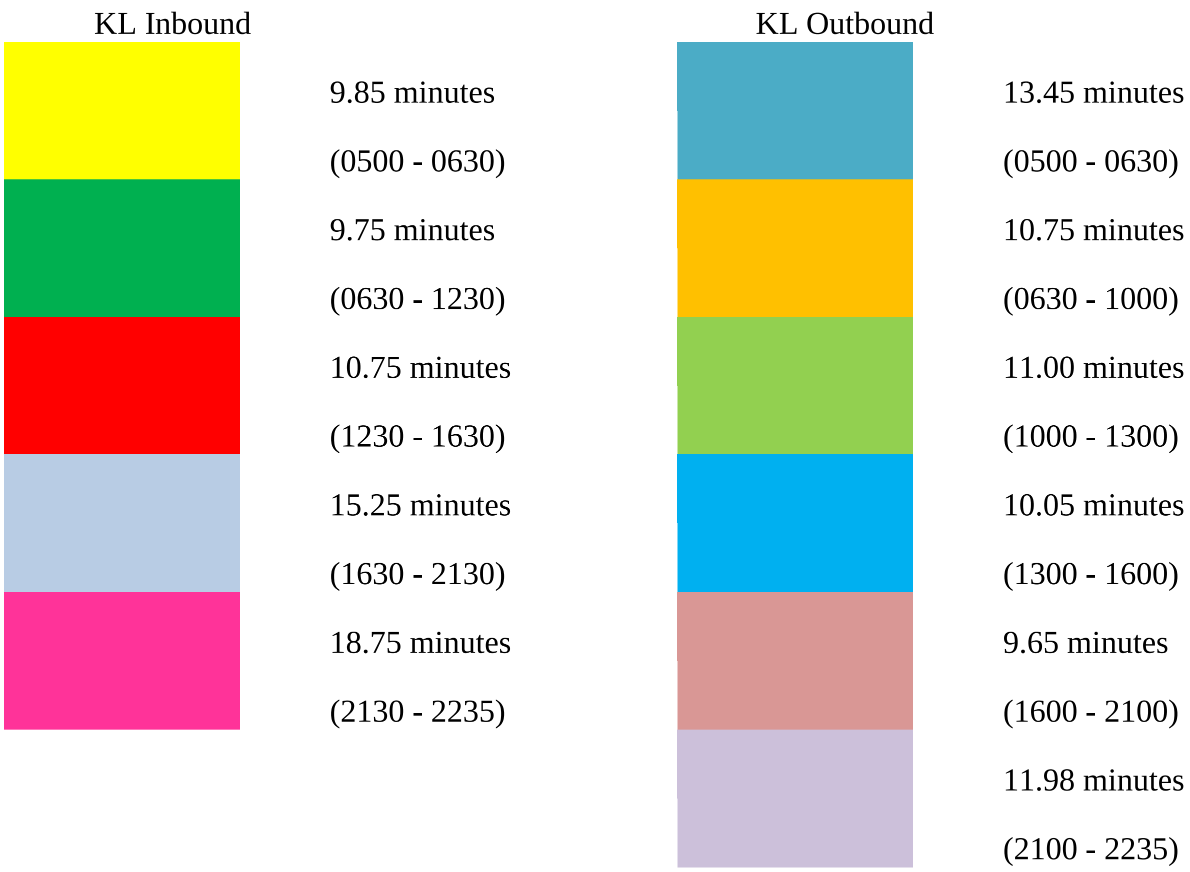


Figure 9.19 Actual Service Frequencies of *KTM Komuter* i.e. the three KOMI commuter train models

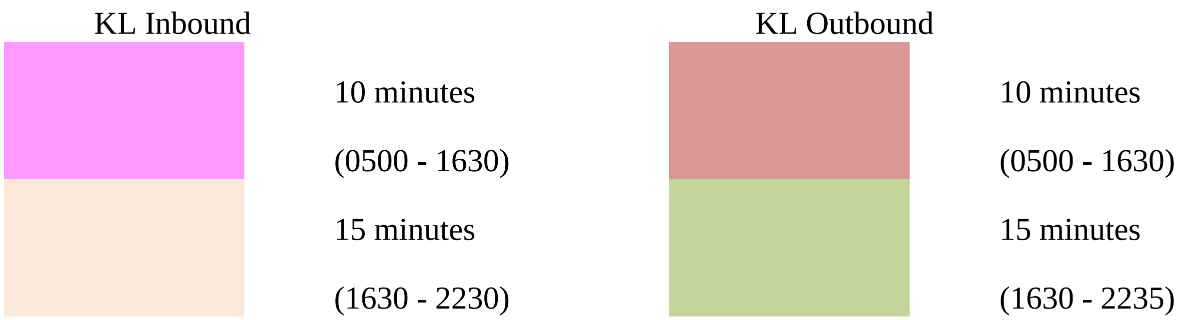


Figure 9.20 Design Service Frequencies of *KTM Komuter* i.e. the three KOMI commuter train models

For the proper management of train supply in the line, the methods of link of train sets to reflect both service frequencies were applied to optimize the 19 train sets for overall operations and to take into account preventive maintenance at the Sentul

Depot. Such schedule examination as Exam A and Exam B would take four hours and eight hours to be carried out respectively. These methods resulted in the Actual and Design Number of Train Sets and the quantities of Actual and Design Number of Train Sets were compared with the two cases of Optimized Number of Train Sets as calculated under Section 9.3 which can be seen on page 386-392. In relatively comparing the totals, these results indicate that both Actual and Design cases clearly require additional trains and may require additional coaches for economical operation. The existing number of train sets since 1994 - 1997: (18 + 22 + 22) equals 62 EMU sets of train for the three KOMI models from Austria, South Africa and South Korea. The existing number of train sets since 2012: 38 MyKomuter EMU sets from the Republic of China (6 train coaches per set) + the previous 62 sets of train (3 coaches per set) accounts for 100 EMU sets of train. However, the rolling stock requirements consider only the stock in 2010 for Actual and Design cases with an additional 66 – 115 sets of train and 46 – 115 sets of train optimized Actual and Design number of trains for KL Inbound and some additional 8 – 143 sets of train and 16 – 143 sets of train optimized Actual and Design number of trains for KL Outbound, respectively. As the rail tracks were subjected to a limited capacity, priority decisions would decide better train and crowd management systems by supplying additional sequence of trains in passing a track and platform (Hale and Charles, 2009; Transportation Research Board, 2013).

Similar to the preceding paragraph, Design Service Frequencies were most needed to design a practical public timetable in the form of excel spreadsheet. The public timetable printouts for both directions were designed based on departure working timetables. In the case of *KTM Komuter,* staggered time was designed for the KL Outbound direction due to limited facilities to enter or access the platform because one of the switch track cross overs had been removed.

KL Inbound Actual Number of Train Sets		Optimized TrainNum		KL Outbound		Optimized TrainNum	
	N*	N1*	N2*		N*	N1*	N2*
0500 - 0630	9	28	32	0500 - 0630	8	18	24
0630 - 0930	22	30	31	0630 - 0930	13	38	24
0930 - 1130	14	26	27	0930 - 1130	9	22	26
1130 - 1430	21	27	26	1130 - 1430	13	27	25
1430 - 1630	15	29	26	1430 - 1630	10	27	30
1630 - 2030	39	12	27	1630 - 2030	13	41	38
2030 - 2400	8	11	8	2030 - 2400	4	26	38
	128	163	177		70	199	205

Design Number of Train Sets		Optimized TrainNum				Optimized TrainNum	
	N*	N1*	N2*		N*	N1*	N2*
0500 - 0630	9	28	32	0500 - 0630	7	18	24
0630 - 0930	24	30	31	0630 - 0930	13	38	24
0930 - 1130	15	26	27	0930 - 1130	9	22	26
1130 - 1430	22	27	26	1130 - 1430	14	27	25
1430 - 1630	15	29	26	1430 - 1630	9	27	30
1630 - 2030	19	12	27	1630 - 2030	19	41	38
2030 - 2400	4	11	8	2030 - 2400	7	26	38
	108	163	177		78	199	205

N* = Optimized Sets of Train using Microsoft Excel

N_1* and N_2* = Optimized Sets of Train from field observation and measurement

Figure 9.21 Actual and Design Optimized Sets of Train from field observation and measurement for KL Inbound and KL Outbound

9.5 SIMULATE IMPACT ON GENERALISED TRAVEL COSTS AND DEMAND

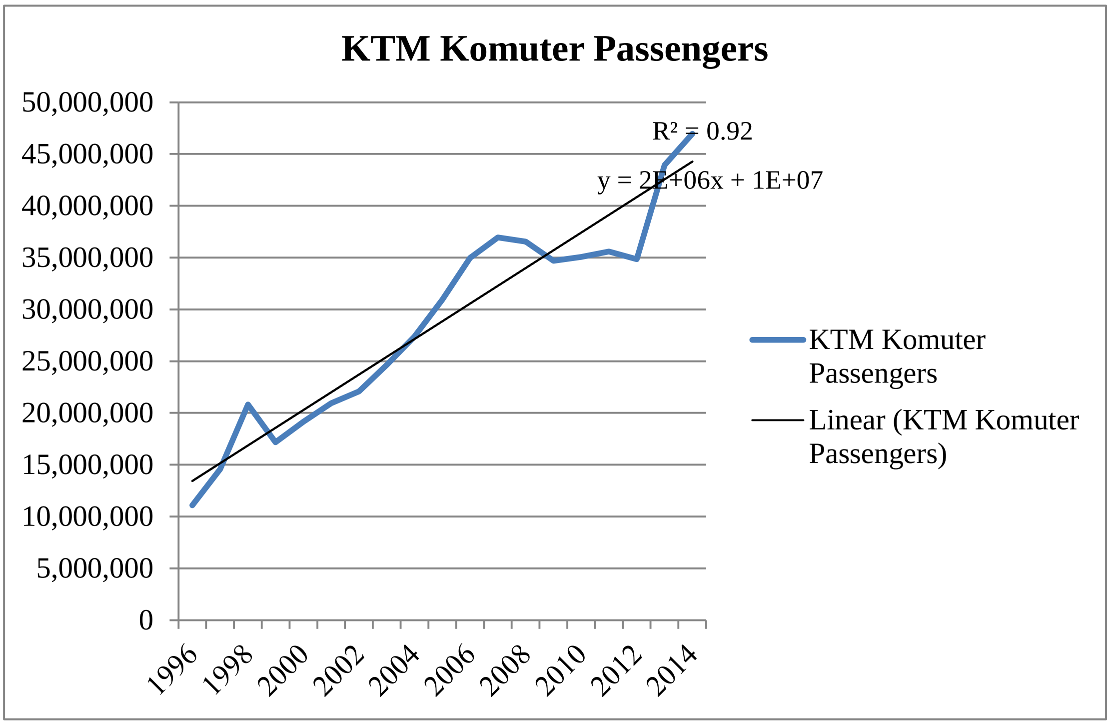


Figure 9.22 Graphical Form of Forecast Demand for *KTM Komuter* for the Port Klang – Sentul corridor

Figure 9.22 is an explorative time-series demand forecasting model for Kuala Lumpur metropolitan *KTM Komuter* rail service for the Port Klang – Sentul line that uses annual ridership (number of passengers) data from 1996 to 2014 on account of the measure of *KTM Komuter* output when estimating effectiveness as reported by Karlaftis and Tsamboulas (2012). The ultimate aim of this medium term forecasting model of rail patronage was to guide timetable, operational and business (particularly marketing) planning (Douglas and Karpouzis, 2009). In the next paragraph, the model is compared to a regression linear line to explain the variation in the year by year change in rail demand for the medium-term trend.

With reference to Figure 9.22, note that the dataset of *KTM Komuter* passengers in 1995 was ultimately dropped out of the graph because of 1995's very low figure (2,817,443 or an average ridership of 20,000 passengers per day in August 1995) compared with the 1996 data which was 11,094,551. There was a huge increase in *KTM Komuter* ridership between 1997 and 2007, thus, illustrating a major portion of graphical representation in comparison to the overall demand for *KTM Komuter*. This is supported by a local evidence from a blog (December 25, 2008, accessed on July 9, 2014), that is, since *KTM Komuter*'s operation in 1995 and the *KTMB*'s failure to plan and manage fleet size through advanced fleet management systems this has caused the fleet size to decrease by 50% although *KTM Komuter* passenger demand had actually tripled. Although the trend was upwards, there was variability in the year by year change. Nor Diana (2012) also reported similar evidence from railway statistics of the Department of Statistics, Malaysia that between 2000 and 2007, *KTM Komuter* registered the highest percentage of passenger ridership, with an average yearly growth of 13.28% compared to passenger ridership for the Kelana Jaya and Ampang LRTs. Chuen et al. (2014) reported that *KTM Komuter* made 100,000 trips daily (1.4%) in the Klang Valley in 2010. From 2007 to 2012, there were constant projections for passenger numbers or its total remaining unchanged which meant both the operation plan and fares of *KTM Komuter* required some adjustments due to different operation plans and fares having different attracting degrees and market share and that the profit and risks of *KTMB* was different in a positive manner. This was clearly pointed out by Hu et al. (2008). There is also little doubt that some incentives derived from the national automobile policies related to car ownership had won over new car users among adults aged 25 years and above over a few years. This affected the growth in demand for *KTM Komuter* services. Other two possible reasons were that the train capacity supply failed to keep pace with the growth in demand, even causing rising investment and strategic planning together with crowding to constrain growth at key times of the day in some cases (Nor Diana, 2012). 'Daily ridership for the services is currently about 95,021.15, with a maximum passenger load capacity of 10,000 pphpd' (Nor Diana, 2012). In more recent years since 2012, the Government has increasingly recognized the importance of improving urban public transport conditions via investments in rail-based public transport systems in which this has led to a sudden rise in the number of ridership from 34,847,247 in 2012 to a total of 43,941,777 in 2013. Above all, the *KTM Komuter* passengers data was linear because the pattern in its data points resembled almost a line suggesting a selection of a linear trend/regression type of line. *KTM Komuter* ridership increased at a steady rate that is from 43,941,777 in 2013 to 46,956,723 in 2014. So, this linear trendline illustrates that *KTM Komuter* ridership has risen consistently over a 18-year period. Note the R-squared value is 0.92, which is a good fit of the line to the data.

KTM Komuter is likely to increase demand and variations in that demand in several ways. These several ways include rail capacity, speed, reliability (Transportation Research Board, 2013), safety, fares, high quality or performance, frequency and accessibility (Nor Diana, 2012, Jansson, 1993, Monchambert and de Palma, 2014). Douglas and Karpouzis (2009) provided factors such as rail LOS, onboard travel time or speed, rolling stock quality, seasonality, tourism, retail activity and advertising, and spend time accessing to the rail network to influence rail demand. Monchambert and de Palma (2014) asserted that increasing patronage would improve service frequency resulting in reduced waiting times and denser route network, thereby causing the service provider to provide external benefits as described by the Mohring effect. In accordance with Jansson (1993), the interaction between fares and frequency means efficiency.

The effect of the optimal services and fares on ridership can be checked by developing an elasticity model. The formula for an elasticity model is as follows:

Optimal Demand/Current Demand

= Oprimal Service Frequency/Current Service Frequency $^{\textit{Service Frequency Elasticity}}$

X Optimal Fare/Current Fare $^{\textit{Fare Elasticity}}$

Since there are no Malaysian values for the elasticities, the following elasticities from The Demand for Public Transport : A Practical Guide is used:

Non UK suburban rail fare elasticity = -0.37; and

rail service elasticity = 0.75;

$$Optimal\ Demand/Current\ Demand\ =\ (6/3.4)^{0.75} \times (1.83/2.01)^{-0.37}$$

Optimal Demand = $(6/3.4)^{0.75} \times (1.83/2.01)^{-0.37} \times 35{,}047{,}933$

Optimal Demand = 55,557,449 i.e demand has increased by 58.5%

9.6 CONCLUSIONS

Having no differentiation between prices during peak and off-peak times has been found more optimal because both the government and *KTMB* as the service provider still intend to increase *KTM Komuter* ridership particularly amongst the low to medium income people and people who do not own and cannot afford car(s) and who do not want to drive cars (see Figure 7.9 in Chapter 7). This is to meet the requirements of the national public transport policies such as social obligation, public welfare and public transport promotion as an alternative to private/personal car ownership (Hale and Charles, 2009, Gschwender, 2007). Based on Gschwender (2007), Preston (2012a) and the *KTMB* management (2014), simplicity is another argument in favour of maintaining cheaper fares in the form of single ticket for more than a decade. Furthermore in accordance with Karlaftis and Tsamboulas (2012), *KTMB* generally produces a public service whose goals should be certainly broader and more socially oriented rather than becoming a company gearing towards profit. More generally and practically, it is not timely to advocate different prices at peak and off peak times because both the level of service and quality of service together with the assets have not been sufficient (lack of availability), efficient (for example, poor travel time) (Muhamad Nazri et al., 2014) and optimal yet (Grotenhuis et al., 2007) like the public transport experience of rail operators in developed countries. These causal factors prevent public transport from being an attractive alternative to a car. So, there is no subsidy issue on fare levels except in service frequency as ridership dictates. This has been simple, straightforward and sensible way to attract the local public like new or potential passengers and who have gradually increased their interest to commute via *KTM Komuter*. Thus, the new *KTM Komuter* fares for Klang Valley sector should be structured based on the current rate of fare (or operating cost per day per passenger-km) of RM0.21 as recently proposed to the Land Public Transport Commission. A merit over service attributes of public transit services is specific attributes of which passengers are most concerned with (i.e.

passenger-value-oriented quality services). Lai and Chen (2011) found these to be vehicle safety, facility cleanliness and complaint handling. These will offer better service quality rather than imposing higher fares to guarantee such services . Passenger-value-oriented quality services must be mandatory (Kumar et al., 2004). However, more efficient fares structures should be devised (May and Roberts, 1995) to balance the recast Continuous Service Quality Improvement and Management undertaken by *KTMB.*

To partially achieve high quality service, conclusions by Givoni and Rietveld (2007), Moniruzzaman and Páez (2012) and Zhao and Deng (2013) reinforced that *KTM Komuter* should enhance the quality of accessibility of station area residents to different activity opportunities and vice versa (Hine et al., 2000) as the improvement in the quality of accessibility may impact their satisfaction with life, SWL directly and, likewise, the improvement in the quality may increase their satisfaction with travel, SWT, then contributing to their SWL (Bergstad et al. (2011) as stated by Cao (2013)) or Hine (2009), Hine (2008) and Preston (2012a) who also mentioned this aspect to enhance well-being and basic needs (quality of life). Accessibility of the station area residents may be thought of as part of the supply function of public transport infrastructure. It is the quality of accessibility of the station area residents to different activity opportunities and vice versa that should be enhanced to partially achieve high quality service. A high quality of accessibility for the station area residents will help increase travel frequency by current passengers and potential passengers from their origins to their destinations. However, *KTM Komuter* has limited service coverage and poor linkages with other modes. This has resulted in high access times (i.e. between 0 and 38 minutes; mean is 10.2 minutes) and egress times (i.e. between 0 and 60 minutes; mean is 9.5 minutes), and very high access-egress costs (i.e. between RM20.23 (£3.45) and RM110.50 (£18.85); mean is RM5.62 (£0.96)) and interchange cost (i.e. between 0 and RM218.00 (£37.30); mean value is RM11.63 (£1.99)) and form a large part of the GTC of rail travel in KL. There are 17 cases (i.e. 4.51%) to illustrate this situation. These 17 cases involve long-distance travelling. The origins most adversely affected are Sungai Buloh, Port Klang, Rawang, Shah Alam, Ipoh (Perak), Cyberjaya, Klang, Gelugor (Penang), Kota Warisan (Sepang), Balakong (Cheras), Subang Jaya, Kuala Kubu Bharu, Alor Setar (Kedah) and Bukit Idaman, Selayang. The highest access and egress costs were recorded by a passenger whose origin was in Section 25, Shah Alam and his final destination was Tanjung Balai, Sumatra, Indonesia i.e. the access and egress costs were MYR110.50 (£21.13).

To partially address one of the key issues of transport and land use planning, Yigitcanlar et al. (2007) also concurred with Hine et al.'s (2000), Hine's (2002), Givoni and Rietveld's (2007), Hine's (2009), Kamruzzaman and Hine's (2011), Curl et al.'s (2011), Preston's (2012a), Moniruzzaman and Páez's (2012), Hine et al.'s (2012) and Zhao and Deng's (2013) idea of enhancing accessibility to needed/desired activities by other modes (i.e. public transport, walking and cycling) other than the use of private cars. This was also supported by Preston and Rajé (2007), Buehler and Pucher (2011), and Lucas (2012) who highlighted the concept of accessibility planning that is highly recommended by the US and German governments and public transport agencies and the UK Social Exclusion Unit by 2003 to the issue of transport-based social exclusion in the British rural areas partly constituting their Local Transport Plans (LTPs) together with land use and service sector. Hine (2002) also concluded that a similar integrated policy approach to that outlined above will promote social inclusion, ensure equal opportunities for all, reduce isolation for those without the use of their own transport and generate local and regional economy. However, Hull (2005) reported that the regional transport strategy had no policies on public transport accessibility in its early drafts. Hull (2005) in addition to the ladder of integration mentioned that the integration of level 7 was required to address issues of mobility and accessibility as an integral part of urban management and design in order to achieve the UK integrated transport strategy, land use, social and sustainable transport planning.

Research undertaken in the US and European cities (for example, Germany and the UK) and Australia by Hine and Grieco (2003), Hull (2005), Gschwender (2007), Hine (2008), Buehler and Pucher (2011), Preston (2010; 2012a) and Lucas (2012) together with several significant research in Australia based on Yigitcanlar et al. (2007) showed the importance of accessibility being evident in coordinated land-use and transportation planning of local councils and state governments. Yigitcanlar et al. emphasized that an accessibility approach in transport evaluation would tackle particular issues like equity and transport disadvantage. Lucas (2012) opined that the poorest (also agreed with Gschwender (2007), Hine (2009) and Kamruzzaman and Hine (2011) as those who did not own a car) and the most socially disadvantaged within society also usually experienced transport disadvantages and inequalities as evident from transport surveys. In the same way, an essential insightful result by Cao et al. (2007) regarding '*An Analysis of Northern California Movers Living in Four Traditional Areas and Four Suburban Areas to Find a Causal Connection from the Built Environment to Car Driving and Walking Behaviour',* revealed that the most significance of increases in accessibility is both reducing car driving and possibly increasing walking. Wibowo and Olszewski (2005) also concurred that good accessibility to access the stations from 400 to 800 m of walking distance or 10 to 15 minutes of walking time can promote and increase Mass Rapid Transit ridership. Wardman and Tyler (2000) as cited by Román and Martín (2011) also had the same idea of rising rail ridership by improving access to train stations. Furthermore, Wibowo and Olszewski (2005) opined specifically that increasing walking accessibility to main public transport can at the same time enhance good public transport service (bus or rail) when there are quality changes to the built environment within the PCA or non-motorised accessibility area of rail stations i.e. 300 - 900 m (Moniruzzaman and Páez, 2012; Zhao and Deng, 2013). A built environment-related Malaysian guideline according to Nor Diana (2012) is that public transport should be located within 400 m walking distance. Several empirical evidence in Europe and Singapore with respect to transfers had been poorly rated by public transport passengers and this belief is emphasized by Givoni and Rietveld (2007), Yew (2008), Syahriah et al. (2008) and Preston (2012a) who also explicitly addressed the quality characteristics of the access and egress modes to and from railway stations by highlighting seamless integration between access and egress modes of transport or also known as seamless multimodal transport because of the inherent inconveniences and transfer penalties occurring in/between different modes of transport and services (from the experiences of the *KTM Komuter* User survey in 2007, Dutch railways and the Singapore Mass Rapid Transit, MRT) and of the distance's friction (as reasons previously touted were also experienced by the British intercity railways) within the access and egress journeys to and from railway stations.

Continuous improvements in the quality of infrastructures and services can affect Public Transport (PT) ridership and passenger demand (Chou and Kim, 2009; Nor Diana, 2012; Irfan et al., 2012; de Oña et al., 2012) and vice versa according to the Transportation Research Board (2013) thus making PT attractive as an alternative to the use of cars like that of a Singaporean's experience (Muhammad Faishal, 2003). For instance, Román and Martín's (2011) research proved that improving access to the High Speed Train stations can increase rail ridership in the Madrid-Barcelona corridor in Spain. However, Murray et al. (2010) concluded that improving the quality of PT service in a city may not improve the residents' attitudes towards PT.

The prospects for further growth in volumes of rail passengers are only good if subjected to the overall economic climate and if adequate funding is received from the government, with there being general acceptance that this will continue to be required to obtain 'optimum service for the money value' from rail services (Frost et al., 2012). Of particular relevance is the requirement to boost the rail industry by attracting more passengers and new passengers to travel by rail in a sustainable way (May and Roberts, 1995; Jiang et al., 2012). It concludes that increasing rail usage is perceived as a key way of achieving Malaysia's sustainability targets for transport (Syahriah et al., 2013). So, it is timely to make necessary investments and gather funding for proper maintenance of railway track and aging infrastructure based on the GTP's Improving Urban Public Transport (Performance Management & Delivery Unit, 2011, accessed on July 9, 2014) and expansion of *KTM Komuter* services (Syahriah et al., 2008; 2013). Perhaps *KTMB* could improve *KTM Komuter* services by building more lines and more extensions to some extent when considering the increasing demand and the 120 km of rail lines proposed in the KL City 2020 Draft Plan (posted on December 25, 2008, accessed on July 9, 2014). To improve the national rail service also means to improve the backbone of a complete public transport network of one economic region in Malaysia.

Based on the findings in this chapter, there is still inadequate network (service) coverage for KTM Komuter service and shortage of rail transport expertise to primarily estimate both capacity and demand. These make the problem statements set earlier under Section 1.2 valid. So, rail transport engineers need to periodically analyze network design features and its operational quality.

Unfortunately, parking facilities and people services are not measured on sites during the passenger on-board surveys and the economic optimisation. This thus suggests that there is no link between combined factor analysis and optimisation for parking facilities and people services. The key findings are recapitulated in Section 10.2. However, more research on this topic needs to be undertaken before the association between Generalised Costs and Demand is clearly understood.

CHAPTER 10 : DISCUSSION OF RESULTS

10.1 INTRODUCTION

The analysis provides four major findings. The resulting Travel Behavioural models, GJT and GTC models, Attitudinal models, KOMIQUAL models, Optimisation models and *KTM Komuter* Timetable are quite informative and policy relevant, highlighting the importance of passengers' overall satisfaction with rail journey and the balance between travel characteristics of the *KTM Komuter* service, the access to the rail station – egress from it and the population served in determining *KTM Komuter* use i.e. personal characteristics of travellers in different parts of the *KTM Komuter* network, attitudinal items, optimized service headway-vehicles-fares and modeled *KTM Komuter* schedules respectively (Jain et al., 2014). There were clear variations in values in accordance with personal and trip characteristics. It is in this chapter that the key findings are summarised from the results of O-D surveys, Attitudinal Surveys and Passenger On-Board Surveys, including Travel Behavioural models, GJT and GTC models, KOMIQUAL models, Optimisation models and *KTM Komuter* Timetable. The following subheadings also elaborate the discussions of results.

10.2 KEY FINDINGS

10.2.1 Key Findings from the Literature

Rozmi et al. (2013) stress that it is timely to analyse how both users and potential users perceive the entire rail-feeder bus services and it would be worth investigating why Malaysian road users who have the experience of using public transport in Selangor and Kuala Lumpur do not favour public transport. Rozmi and two other researchers summarize these travel attitudes and behaviours into two general parts that are satisfaction and punctuality.

Cunningham et al. (2000), Kumar et al. (2004), Huisman et al. (2005), Beirão and Sarsfield Cabral (2007), Hirsch and Thompson (2011), Lai and Chen (2011), and Nurul Habib and Zaman (2012) believe that gaining a better understanding of users' perceptions, attitudes and behaviours related to the quality of service provided by public transport and modelling the associated generalized travel cost are also important for successful service quality management. Chou et al. (2011), Irfan et al. (2012) and de Oña et al. (2012) also emphasize the importance of identifying the users'-oriented service attributes for true user-based, well-organized and thriving service strategies. According to Irfan, this trend is visible in developing countries.

10.2.2 Key Findings from the O-D Surveys

The Travel Behavioural models were produced based on O-D surveys. These travel behavioural modelling are also known as multimodal passenger transport modelling in accordance with Amiruddin et al. (2012). These O-D surveys involved intermodal trip chains from the point of origin to the destination point. Similarly, these O-D surveys highlighted the vital role of accessibility in the link of Land Use System (Supply) with the elements of the entire Mobility of each category of people and the Transport System (Multimodal Transport Planning processes) (Hine et al., 2000; Hine, 2008; Curl et al., 2011) and vice versa, which are formed by infrastructure (including superstructure and intermodal links), networks or the choice of routes, services, locations of transfer between modes of public transport (Amiruddin et al., 2012) and, interactions of social (that is, society and transport-related lifestyles) and economic agents (Halden, 2002 as cited by Hine and Grieco, 2003; Hine, 2002; Yigitcanlar et al., 2007; Too and Earl, 2010), each of them on its own a complex whole. Amiruddin et al. (2012) opined that the significance of multimodal transport planning processes enhances the efficiency of planning integrated modes of transport.

The following are the summaries of results from the analysis of complementary mode shares with a focus on accessibility to/from the train system considering primarily the local conditions at the point of origin of trips, in other words, the ease of entering the train system. This ease must be contrasted against the ease of reaching attractive destinations. In other words, the accessibility produced by the train system must take into account the point of destination locations. The origin and destination *KTM* railway stations with the highest proportion of boarding passengers were KLS, Subang Jaya and Shah Alam. KL was the most frequently recorded place of origin and destination followed by Shah Alam and Subang Jaya. Modelling the route choice of the users, passenger flows were identified primarily on directions such as city destinations (57.6% trips), Pelabuhan Kelang (34.2%) to the western regions of Peninsular Malaysia, Sentul (33.7%) towards city centre and to the northern part of the outer KL city centre, and heading south i.e., Seremban (11.1%). Commuter survey data collected indicate mode shares for the case of commuting regularly at least five days a week to once a week to work and home was at 65.3%. On average, the valid sample of 373 passengers had begun to use *KTM Komuter* in 2003.

Of particular interest for this research as mentioned earlier in this paragraph is the effects of accessibility to the *KTM Komuter*, and accessibility by *KTM Komuter* for a single or one way trip, which is defined as the usage or choice of complementary multimodal transport that accounted for approximately 77.0% and 60.0%, respectively. The remaining percentages represented the category of complementary unimodal transport i.e. the access transport modes ranging from walking (21.8%), travelling by taxi (1.1%) and car as used by the passengers (0.3%) whereas the egress modes of transport comprised walking (40.1%) and car used by passengers (0.3%). These proportions of walking to-from access-egress the *KTM Komuter* were comparable to those reported for the Bay Area Rapid Transit, San Francisco, Tokyo Metro and Netherlands' rapid transit system and conventional rail system i.e. more than 20% and 40% respectively from the results of Wibowo and Olszewski's (2005) walking accessibility model. Surprisingly, 40.1% and 32.2% of the *KTM Komuter* users fully used public transport to and from the surveyed railway stations of origin and destination respectively. There were 12.5% public transport captive riders with no private vehicles available for the trip and 51.1% of them involved females. On the contrary, 87.5% and 53.8% of the *KTM Komuter* passengers had great access to private vehicles and car trips, correspondingly. Meanwhile, female users accounted for 63.8% from the 46.2% of the *KTM Komuter* commuters who did not drive for the trip. *KTM Komuter* stations were highly accessible via public transport (40.1%) and by walking (20.8%) compared to 27.1% who used private vehicles whereas some 32.2% public transport and 39.3% walk and bicycle egressed from the *KTM Komuter* stations compared to 26.1% private vehicles, indicating the passenger catchment areas may be adequately large but the lack of feeder buses might reduce the expected number of passengers to and from the *KTM Komuter* stations.

Multimodal transport termed private-public transports were estimated at 12.0% and 2.4% to-and-from the surveyed railway stations, respectively. Of the 12.0%, they were car-bus, car-express bus, car-*KTM Komuter*, car-Ampang/Sri Petaling LRT, car-KLIA Transit, car-Kelana Jaya LRT, motorcycle-Kelana Jaya LRT, motorcycle-*KTM Komuter*, and motorcycle-bus-Kelana Jaya LRT modes of travelling. 2.4% private-public transport to final destinations involved car-Ampang/Sri Petaling LRT, car-KLIA Transit, car-Kelana Jaya LRT, car-*KTM* Shuttle train, car-express bus, car-*KTM* Electric Train Shuttle, motorcycle-Kelana Jaya LRT, and motorcycle-bus. This signified the use of mixed access and egress modes of transport which then caused poor physical and system integration of rail-related public transport in the vicinity of KL and the Klang Valley. Similarly, passengers suffered discomfort and inconvenience due to many transfers (i.e. eighth station transfers), stages (i.e. four to fifteen), between three and eleven multimodal transport modes, and between six and twenty three number of parts within the urban multimodal transport trip in order to get to their final destinations. The associated number of transfers was from one (39.3%), two (3.7%) to three (0.3%). These findings presented the information on planned transfers and their influence on timetable stability in case of delays. In addition, the transfer time at both railway stations of origin and destination were 35 minutes and 25 minutes respectively. The corresponding mean walking time was estimated to be 10 minutes for the 377 cases and involved four types of transport namely NMT, MT, NMT - MT and O. With reference to *KTM Komuter* passengers who only walked to-and-from rail stations, the respective mean access - egress walking time was approximately 14 minutes and

12 minutes. Among the valid observations, 58.3% and 61.8% of the walk commuters were females who accessed to and egressed from rail stations. More than 80.0% of the commuters who walked were between the ages of 20 and 49 at both entrance and exit rail stations, and 81.0% who accessed rail stations reported a household monthly income between RM500 and RM3999 whilst 70.5% who egressed from rail stations reported a household monthly income between RM500 and RM2999. 74.7% of the commuters who walked to the rail stations of origin had two, three and five people (over fifteen years of age) living in the household, including the respondents whereas 70.5% who walked from the final rail stations had a family size of between two and four people of above fifteen years, including the respondents. The walk commuters' occupation who accessed-egressed to-from the rail stations were private staff (41.7%), general workers (15.5%), students (14.3%) and private staff (38.1%), government staff (16.4%), and students (14.5%) respectively. The respective status of employment had about the same pattern at both the entrance and exit of the rail stations i.e. roughly 76.0% of them were full time staff, less than 20.0% were unemployed because they were students, housewives, and a retiree, and no more than 5.0% were part time personal businessmen and businesswomen, private and professional staff, and general workers. 56.0% of the commuters walked during the evening peak to the rail stations of origin at access time. The breakdowns were 10 minutes (19.1%), 5 minutes (17.0%) and 15 minutes (14.9%) and this fraction decreased to more than double for the commuters to egress from the final stations during the evening peak. The breakdowns were 10 minutes (39.5%), 5 minutes (28.9%) and 15 minutes (13.2%); 39.1% also walked for 10 minutes during morning rush from the final rail stations, 37.9% and 29.0% also walked during late comer period and during

afternoon peak for 5 minutes to exit the rail stations respectively and 20.7% were also walked from the final rail stations for 15 minutes. 75.0% and 83.6% of the commuters walked during sunny days to-from the rail stations and the corresponding breakdown was 10 minutes (20.6%), 5 minutes (15.9%) and 15 minutes (9.5%), and 5 minutes (27.6%), 10 minutes (23.6%) and 15 minutes (15.7%).

The Cross-Tabulation Results of the Descriptive Statistics Analysis indicated that the access walk distance in the evening peak was longer than that in the morning peak. Young commuters' in their 20s and 40s walked farther to access rail stations than teenagers' aged less than 20 years old and older people of 65 or more. The access walk distance decreased with increasing monthly household income. The mean access walking distance was 892 m. 41.0% of the commuters who walked 300 m, 350 m and 450 m consisted of family with two and seven members. This implies that these results were consistent with the lower range of the rail-based TOD's walking distance guidelines in Canada and the US. The different categories of commuters in Mumbai, India and Riyadh, Saudi Arabia walked about two to three times longer (i.e. 859 m to 910 m) or walked 65 m/min faster than young Malaysian commuters as reported by Rastogi and Krishna Rao (2003). Rastogi and Krishna Rao reported the mean walking and bicycling distances obtained in their study and compared theirs with the findings from other cities/countries. Their efforts displayed a mean access walking distance of 892 m which was comparable to those reported for Beijing (22.5 minutes) and Ningbo (20.0 minutes) in China, Riyadh, Saudi Arabia and Mumbai, India. 41.7% of them who walked 300 m, 350 m and 450 m were private, semi-government and government staff, students, a housewife, an unemployed individual and a general worker with 74.3% and 5.7% out of 41.7%

being full time and part time staff respectively. The part time staff walked 350 m to the rail stations of origin.

The Cross-Tabulation Results of the Descriptive Statistics Analysis also indicated that the egress walk distance in the evening peak was longer than that in the morning peak. Young commuters' in their 20s and 40s walked farther to egress from rail stations than teenagers' aged less than 20 years old and older people of 50 to 64 years old at equal percentage. The egress walk distance also decreased with increasing monthly household income. The mean egress walking distance was found to be 623 m. 28.9% of the commuters who walked 200 m, 300 m and 450 m egressing from the final rail stations to their destinations came from a family of between one and fifteen and were employed privately, in the government sector and a *KTMB* staff, students, a housewife, an unemployed individual, self employed people, general workers and professionals with 65.9% and 2.3% out of 28.9% being full time and part time staff respectively. A part time staff walked 200 m egressing from the final rail station to his destination. From the above findings, it is not clear whether the access and egress walking distances are longer to access and egress from the *KTM Komuter* stations than to access and egress from buses. Walking trips in the commuting evening peaks are significantly longer than trips in the commuting morning peaks. This also means people walked to access the *KTM Komuter* stations similarly to that commonly assumed as 'rule of thumb'. Another concluding remark is that the walking speed estimated from the present research also supports the evidence of a previous research by Mateo-Babiano and Ieda (2007) as cited in Jiang et al. (2012), that Westerners and Japanese walked faster than Asians in developing countries.

The mean access-egress travel time were found to be 35 minutes and 25 minutes. As a result, KTM Komuter passengers underwent such a very long non-ride time that impacted total travel times. This summary of transfers was consistent with those of Ceder's (2007) US trip data and Scheurer and Curtis's (2008) Australian urban public transport networks. They found a standard maximum transfer for a service design at planning level to be three. Meanwhile, 52.0% of return transport modes were multimodal transports. The findings from the multimodal choice surveys and travel behaviour profile of *KTM Komuter* users from this present research provide significant contributions to the current literature. Unlike the findings of Daniels and Mulley (2013), *KTM Komuter* trips were shorter than bus trips, both in distance and time.

On average the travel costs were about RM3.35 (£0.69) to reach the stations of origin and only RM2.73 (£0.56) to get to the final destinations. Mean travel distances to-and-from railway stations for the 377 cases were 13.6 km and 8.7 km, thus strongly concluding the substantial number of stages happening within the access and egress trips and hence, the common use of mixed transport. With reference to the British experience on the importance and principles of public transport integration (May, 1993; May and Roberts, 1995; Hine et al., 2000; Potter and Skinner, 2000; Hull, 2005; May et al., 2006; Preston, 2010; 2012a), the integration of Walking and PT showcased a 36.9% and 32.2% (i.e. access and egress Walking-PT Integration) competitive door to door alternative to private car for medium to long distance single trips. From the 2010 dataset of O-D surveys, the corresponding mean access and egress travel distances for Walking-PT Integration were found to be 15.0 km and 13.1 km. Using Walking-PT Integration with the ease of reaching services, major activity centres and/or mix use development, these are conceived as fundamental components of effective integrated land use and transport strategy based on the better practice and integration of transport, land use, planning, commercial property, urban design and environment techniques developed by the Department of Transport in Brisbane, Queensland Government (Yigitcanlar et al., 2007) and the concept of Transport Development Areas, TDAs found in Melbourne, Sydney and Auckland in ensuring suitable outcomes like adequate public transport asset and capacity, integrated TDA approach, co-ordinated delivery among others (Hine, 2002). Buehler and Pucher (2011) reported that most German cities had well-integrated walking and cycling facilities to complement public transport in the early 1970s. Similarly, in view of the impact of transport integration measures on the UK demand resulting from the British work on Smarter Choices, sustainable infrastructure such as innovative walking and cycling routes were considered (Preston, 2012a). The associated mean access and egress travel cost incurred by *KTM Komuter* passengers while Walking-PT Integration was RM4.20 (£0.77) and RM6.16 (£1.13). The highest cost incurred during access travels was RM1.00 (£0.18) (15.3%), RM1.60 (£0.29) and (8.0%) and RM2.00 (£0.37) (7.3%). During egress travels, *KTM Komuter* passengers spent RM1.00 (£0.18) (22.5%), RM2.00 (£0.37) (7.5%), RM6.00 (£1.10) (7.5%) and RM8.00 (£1.47) (5.0%). People were more likely to drive because the car journey to the *KTM Komuter* stations was convenient and there was good, reliable provision of park-and-ride services to allow them to continue their journey using the *KTM Komuter* as the main mode of transport. This present research has been found to overperform The Land Use and Public Transport Accessibility Indexing Model (LUPTAI) approach in Queensland, Australia to measure the ability to access common Land Use Destinations (LUDs), for example, health, education, retail, banking, and employment by walking and/or public transport and the traditional method of measuring accessibility by road or Euclidean distances based on Yigitcanlar et al. (2007). This is the first of its kind in the Malaysian context to consider a range of modes, including public transport, use of car, walking and cycling as means of access and egress to and from rail stations.

Walking was preferred by about half of the low income (< RM2000 = £412.02) *KTM Komuter* passengers i.e. 41 passengers (48.8%) and 80 passengers (53.0%) to access and egress from the *KTM Komuter* stations, respectively. These results were similar to the related results i.e. low income households chose to walk the most in all the journeys mentioned by Hine (2009) and (Grayling, (2002); Hine and Mitchell (2003) as cited by Hine and Grieco (2003)). About 50.0% of the low income passengers chose public transport as their dominant mode of transport to reach and to egress from *KTM Komuter* stations, 52.8% and 47.5%, respectively. Hine (2009) highlighted that low income households in particular the non car-owning in the lowest income quintile preferred walking and using public transport the most and this is similar to the findings of Kamruzzaman and Hine (2011) which also indicated that a higher number of low income individuals were actually non-car owners that fully relied on public transport. Some 21.3% of the low income group (< RM2000 = £412.02) did not own a car and chose to walk and use public transport to reach *KTM Komuter* stations. Only 5.3% and 13.3% of the low income group with no car were provided lifts by car-owning friends and chose to walk to the stations respectively. By contrast, still referring to the same group, 19.3% were found walking and using public transport to reach their final destinations. While, 5.3% were also provided lifts by their car-owning friends, 28.1% walked and only 1.8% cycled from the *KTM Komuter* stations. At least, trends in transport use and patterns of travel (Kamruzzaman and Hine, 2011) seemed to accentuate the importance of accessibility and personal mobility to and from *KTM Komuter* services for the transport disadvantaged (Hine, 2008; 2009; Hine et al., 2012). Also, *KTM Komuter* users from low income households experienced higher access and egress times to and from rail stations by walking and using public transport as also noted by Hine (2008) in his discussion on patterns of transport disadvantage. 58.3% of the *KTM Komuter* passengers who walked to access *KTM Komuter* stations were women whereas 62.3% female passengers egressed from *KTM Komuter* stations, compared to men. Women were also more reliant on public transport than men. Women made 67.6% of trips by public transport to access *KTM Komuter* and 65.0% of trips by public transport to egress from *KTM Komuter* stations. From the above evidence, it can be concluded that women's travel patterns were more complex than those of men. This is also supported by some studies in the US and other countries including France and the Netherlands as stated by Rosenbloom (1989 as cited by Hine and Grieco, 2003) and Hine (2002).

The average journey time on *KTM Komuter* and average actual waiting time during week days and during the weekends were estimated to be 38 minutes and 17.5 minutes respectively. This average journey time on *KTM Komuter* was total riding or in-vehicle time between O-D stations. 13.5% of the passengers had to wait 15.0 minutes for the *KTM Komuter,* 12.2% waited 20.0 minutes while 11.1% waited 10.0 minutes. Using the 2002 British Guidelines on Passenger Demand Forecasting (PDFH), the average journey time was 115.5 minutes and the average journey cost was RM9.71 (£1.86). The empirical evidence concluded that the average waiting time was more than half the scheduled headway because of unreliability. On top of that, the average waiting time of 17.5 minutes was found slightly higher than the range of theoretical average waiting time of between 5 and 15 minutes as discussed previously under Section 6.3 and was about the same as that of Syahriah et al.'s (2013) finding, indicating that the situations in early 2010 i.e. during the survey periods remained about the same as those in 2008 and 2009.

The mean *KTM Komuter* fare was RM3.60 (£0.66) with a maximum of RM30.82 (£5.65) charged to the passengers. About 95.0% of the passengers were in the fare category of adult and no more than 2.0% were categorised as senior citizens and adults accompanied by children. As high as 69.2% of the passengers bought single adult tickets, approximately 12.0% of them were categorised as return adult tickets and 0.8% had tickets signalling single or return adults and children aged between 4 and 11. The frequency analysis of quantity of tickets for *KTM Komuter* ride resulted in 66.8% of the passengers agreeing that they was one adult, followed by two adults (7.7%) and 4.5% included more than two adults. Almost 60.0% of the users bought tickets at the counters. 20.4% used Ticket Vending Machines and 13.0% used magnetic-stripe tickets as modes of payment for the *KTM Komuter* ride. Only 4.5% paid for services using a monthly pass. There was such response as none (as many as 1.6%) for fare category, 15.1% for type of tickets used and 19.9% for quantity of tickets for *KTM Komuter* trip due to no information or answers obtained from the respondents or missing or left blank answers.

To describe the *KTM Komuter* passengers' profile, 91.5% represented adults with no restriction covering ages from 20 years to 64 years. The respondent pool was of an average age of between 20 and 39 years, with a minimum of less than 20 years and a maximum of between 65 years and above. About 73.0% were adults with no guardians, and with physical and disability restrictions. Some of the 4.8% of the users were pregnant women, disabled persons, elderly persons and wheelchair-bound users who requested for convenient, special user-friendly and priority accessible services owing to these pertinent provision of services and facilities being poor in quality. There were roughly 64.0% women riders. A majority of the passengers ranged from full time private staff (42.7%) to (19.6%) students to (11.4%) full time government staff. 47.5% of the *KTM Komuter* passengers were categorized in the low income group where they earned less than RM2000 (£412.02) per month. *KTM Komuter* was also the preferred mode of travel among the users. This accounted for 20.4% among those with a monthly income in excess of RM3000 (£618.02).

The resulting GJT and GTC were quite high suggesting the propensity of these determinants to be deterring factors to the passengers for choosing *KTM Komuter* as the main transport mode. Such GJT and GTC provide supporting evidence that the previously defined research hypothesis under Section 1.5 of increasing train efficiency in terms of service frequency to reduce both GTC in units of money and GTC in units of time (or the total weighted travel times) and the latter would in turn justify reduced GJT.

10.2.3 Key Findings from the Attitudinal Surveys

The summaries of results from the Attitudinal surveys were initiated by the Analysis Results of Travel Reasons. Nearly one third of *KTM Komuter* passengers did not have private vehicle(s) for their trips. About 29.0% wished to avoid bad traffic and 25.0% preferred paying cheaper fares. Hence, this suggests the need to use *KTM Komuter*. The Users' Satisfaction surveys showcased that a proportion of *KTM Komuter* Captive Riders of approximately 65.0% did not own private vehicles.

Roughly 54.0% did not want to drive private vehicles and almost 1.0% cannot drive private vehicles at all. Therefore, this caused dependency on the *KTM Komuter*.

There were only 45 service attributes for conducting Attitudinal Surveys because respondents tended to give biased responses if there were too many attributes in the questionnaires. Users' Satisfaction surveys summarised that about 63.0% of the users were satisfied with the fare structure. 88.7%, 79.9%, 78.7% and 75.0% of users' dissatisfactions were mainly on the special public amenities available for family, babies, feeder bus services and handicapped persons respectively. Most of the users responded that they were dissatisfied with the timetable- and performance-related features incorporating frequency, schedules and reliability/punctuality. Nearly 55.0% of respondents were highly dissatisfied with the total travel times of the trains and 57.8% of them were also highly dissatisfied with the timetable (schedule). For these reasons, almost 60.0% of the users were unhappy with the current *KTM Komuter's* reliability/punctuality as a result of congested platforms and trains to a large extent. Approximately 19.0% to 46.0% of the passengers were fairly dissatisfied with the non-timetable journey related service quality attributes, such as rolling stock, level of crowding with respect to availability of seats and the standing space, station facilities, on-board train service and information provision as well as private vehicle user's provision such as car (driver)-, car (passenger)- and car (driver, shared)-based facilities. Meanwhile, 14.7% were satisfied with the LOS, thereby indicating that 93.0% of the *KTM Komuter* users rated the overall service quality to be from fair to very poor for features such as riding quality, riding comfort, convenience, staff courtesy and customer services. Nearly 30.0% rated riding quality and riding comfort to be good although only about 15.0% responded both seat availability and standing space to be of good quality (see

Figure 7.16), 84.0% stated that they were fairly satisfied with the current convenience use of *KTM Komuter* even though they had to rely on a high number of transferring modes, and approximately 41.0% and 46.0% of the users were very satisfied with *KTMB*'s hospitality service with respect to customer services and staff courtesy, respectively. Similar to the results of Chowdhury et al.'s (2014) research, 82.5% rated transfer facilities to be fair to very good indicating 'planned' transfer facilities (for example, staircases, escalators, same-level cross-platform interchanges) in the *KTM Komuter* network were likely to increase reliability (i.e. it reduced transfer walking and waiting times) and convenience, thus upgrading *KTM Komuter's* image. Therefore, there is need to improve the *KTM Komuter* system performance and the LOS. To strongly support the results of the *KTM Komuter* passengers' satisfaction levels on the overall services, facilities and *KTM Komuter* provisions, passengers were invited to make suggestions and forward other comments. So, the next step was to carry out basic data analysis beginning with editing and coding survey data, inputting them in the computer in a software-readable format, doing basic or descriptive statistics analysis such as frequency distribution and means and cross-tabulation analysis to generate insights and finally resorting to higher order analyses such as factor analysis and SEM-AMOS.

62.6% of the users' participated in the section of suggestions and other comments. This user group involved regular passengers. They were familiar with the service and they may perceive the service more favourably than the non-passengers. Their suggestions and other comments were to improve *KTM Komuter* service quality with regards to timetable and non-timetable journey related attributes and performance variables namely service frequency (28.6%), comfort and convenience (24.2%), schedules (19.3%), reliability/punctuality (12.6%), stations, platforms and train coaches quality (4.4%) and safety and security (3.6%). Such survey results may further improve the travel time and the quality of services of *KTM Komuter*.

To describe the *KTM Komuter* passengers' profile, the largest group of users was between the ages of 20 and 39 years representing 76.5%. 72.7% of the passengers were females suggesting that young females comprise a larger population of public transport users compared to male users. About 96.0% of the *KTM Komuter* passengers were Malaysians. 19.6% had four persons above fifteen years of age in the household. Household size of two represented 19.1% whereas 17.5% had five household members. A majority of the passengers ranged from full time private staff (41.5%) to (32.7%) students to (13.7%) full time government staff. 75.8% of the *KTM Komuter* passengers were adults. Roughly one third of the adult users were students who represented the dominant group with no guardians, physical and disability restrictions. 48.2% of the passengers earned a monthly income of less than RM2000 (£412.02). These results of 47.5% and 48.2% of the *KTM Komuter* users (from O-D and Attitudinal surveys) earned below RM2000 (£412.02) were about the same as that of the *KTM Komuter* User survey done by Syahriah et al.'s (2008) in 2007. Therefore, 69.6% of the total users can be categorized in the medium to low income groups that were paid RM2999 (£617.82) or less per month.

First, from a statistical standpoint, the Summary of Results of Convergent Validity Test of the statistical modelling suggest that service quality attributes such as main and additional services, and personnel particularly parking facilities, train efficiency, people services and space comfort have the highest positive effect on service quality. Attitudinal surveys relate to the quality of each service variable with importance assigned to it. In other words, the KOMIQUAL models helped to identify important determinants of *KTM Komuter* high service quality that the passengers considered to be priorities. Results of Preston's (2001) and Syahriah et al.'s (2013) research also confirmed on the need to groom personnel and this in turn provide evidence supporting the previously defined research hypothesis under Section 1.5 i.e. improving soft services and, technical and professional skills pertaining to customer services (Buehler and Pucher, 2011, Wardman et al., 2001) and staff courtesy, respectively. Moreover, application of an advanced modelling technique can be used to reveal very interesting details for managers, government and public transport operators, since it gives them benefits in the form of valuable information on which aspects can effectively impact decision-making processes to promote the use of *KTM Komuter* (Preston, 2001). They can set out policies aimed at capturing specific types of users based on such information.

The respondents of the two surveys discussed above were not completely random because the age groups 'younger than 20', 'older than 65' and disabled people were under-represented.

On the basis of Dell'Olio et al.'s (2011) work, the desired QOS tools may help improve public transport planning within a setting of sustainable mobility. In Dell'Olio et al.'s (2011) work, passengers who expected or desired QOS was practically limited to waiting time, cleanliness and comfort (which could be considered equivalent to Frequency and Comfort) whereas key public transport variables that potential users valued were waiting time, journey time and level of occupancy (which could also be considered equivalent to Frequency and Comfort) when defining an efficient public transport service. Syahriah et al.'s (2013) output of study concerned perceived frequency, adherence to schedule and delays.

The histograms of the SWT and SWL statements generally have a long left-hand tail. That is, most respondents were satisfied with their travel and life to some extent. The above graphs illustrate that the changing of passenger demands in terms of their flows at stations obviously fluctuated daily at different intervals. So, these situations would necessitate *KTMB's* Department of Operation to solve the notable problem of *KTM Komuter's* efficiency, particularly, as their core business is in the running of trains (Givoni and Rietveld, 2007). This can be done by providing a systematic train operation schedule (Huang and Niu, 2012) and a suitable signalling system (Ke et al., 2012). During the research period, the *KTM Komuter* operations were found to be irregular during every journey probably due to the different kinds of train-sets operated on fixed railway sections regardless of train-sets being utilized completely during peak periods (even though *KTMB*'s plan in 2007 was that the 5-minute frequency during peak time was realistic and their main goal).

10.2.4 Key Findings from the Optimisation Models

The research optimization problem is easy to solve analytically. A summary of Results of Optimisation Models shows that optimal headway decreases while the optimized number of trains increases to meet increased passenger demand, which also means that the adherence to schedules would be optimized accordingly. A practical operating service headway should be 10 minutes during 0500 – 1630 hours and 15 minutes during 1630 – 2235 hours for both ways. This finding clearly supports the evidence from in-depth interviews involving car users' perception of public transport undertaken by Hine and Scott (2000) who opined that a good public transport system should frequently service every 15-20 minutes. Buehler and Pucher (2011) have reported that the contributing factor to the successful German public transport in German cities were the strong integration of transit services, fares and schedules since 1996 whereas the integrated bus and rail in the US has recently resulted in higher number of passengers and more value for money. From a policy standpoint, the analysis indicates the need for a marketing message that emphasizes lower stress levels and better commute time productivity (i.e. time-saving) with reference to the work of Popuri et al. (2011) and Feng (2011).

Detail travel and activity data together with socio-economic characteristics characterised the locations, movements and activities of passengers (Kamruzzaman et al., 2009). Based on data analysis, *KTMB* must, therefore, consider three aspects when considering how to improve its service: the importance of each factor for the passengers, their current levels of satisfaction and the likely cost of improving the quality (and thus the satisfaction towards) of each factor.

Part of Cao's (2013) findings related to residents' perceptions of LRT access and services and their perceived easy access to activity destinations could provide an explanation that LRT partially improves residents' satisfaction with life. He proposed to planners that accessibility enhancement be made by both access to rail service and connection between residential areas (or station areas) and numerous regional activity destinations. The former suggestion potentially expands residents' travel choices, enriching their experience (Gärling and Axhausen, 2003) thus improving their travel satisfaction. He also claimed that the high parking costs at most major land uses along the Hiawatha line and the possibility of limited car parking facilities near stations as mentioned in a study by Givoni and Rietveld (2007) help improve the relative accessibility of LRT in the Minneapolis-St. Paul metropolitan area (Twin Cities) in the U.S. and of the Dutch railways, respectively. Givoni and Rietveld (2007) supplemented that restructuring of accessibility of stations be inexpensive and its costs of changes be more reasonable compared to those of the overall rail journey. Furthermore, cycling, public transport (referred to Bus/Tram/Metro) and walking are dominant modes of travelling among the rail passengers to get to and from the railway station (about 85% and at least 90%, respectively).

In the context of limited resources and money for investment in rail infrastructure, vehicles and crew, and if the aim is to increase rail use (mainly by attracting passengers from the private car), estimating service quality, the effects of land use, social and economy, the proportion of car use, environmental quality and health are crucial in planning the development of a rail network (Ahern and Anandarajah, 2008; Too and Earl, 2010; Gallo et al., 2011; Nurul Habib and Zaman, 2012). Other than limited resources and finances, institutional barriers which restrict co-operation in planning and operating services of different transport modes might hinder improvements which can make rail a more attractive option to travellers.

An estimation of the number of *KTM Komuter* train sets using the ROMAN-D software to design timetable concluded that passenger density and frequency of *KTM Komuter* service can help to increase the number of *KTM Komuter* train sets to be operational or extensively used (Moniruzzaman and Páez, 2012), thus resulting in more train sets being needed with double coaches per set (Syahriah et al., 2013). Or, perhaps the primary, smart solutions are to purchase a new type of EMU and expand the routes (Syahriah et al., 2008). The present analysis of a need to increase the number of train sets provides additional evidence with respect to the backlog of existing rolling stocks. This provides evidence supporting the previously defined research hypotheses under Section 1.5 of decreasing a train's stop time at every rail station by improving boarding/alighting time and by providing convenience with wider doors and/or a few doors. The demand and supply interactions of the *KTM Komuter* are examined such that the trade-off between economically efficient operation and adequate service for the public is very complex and may require intensive analyses and pertinent decisions.

The summaries of results of travel time, reliability, the quality of the station and the service schedule provided empirical proof that *KTMB* had planned to improve the *KTM Komuter* station facilities to help commuters deal with unacceptable long waits that plagued the system (posted on September 20, 2011 by transitmy and accessed on June 20, 2014) and that this *KTM Komuter* station-upgrading was targeting to increase rail demand on the basis of the GTP's Urban Public Transport National Key Results Areas (NKRA) (Performance Management & Delivery Unit, 2011, accessed on July 9, 2014). The Malaysian GTP's targets in achieving 25% public transport modal share are to enhance public transport performance with regards to reliability, travel time, comfort, accessibility and connectivity (Syahriah et al., 2013). Too and Earl (2010) also found similar service attributes for most commuters within Varsity Lakes in Gold Coast, Australia who rated frequency, connectivity and integration between the different modes of transport as vital. A variety of time, comfort and price would define the multimodal and intermodal of public transport as stated by Filippi et al. (2013). It is probably more feasible and cost efficient to achieve improvements in the quality of the access-to-station facilities - especially for the smaller stations on the network. This is evidenced by the Dutch and the American surveys of Brons et al. (2009) and Cao (2013) respectively and the literature of Cervero (1993) as cited by Zhao and Deng (2013). On top of this, the passenger surveys of the present research provides additional evidence with respect to achieving improvements in the quality of the access-to-station facilities - especially for the smaller stations at the Port Klang – Sentul line such as Angkasapuri, Pantai Dalam, Petaling, Kg. Dato' Harun, Jalan Templer, Seri Setia and Setia Jaya from the level of usage of *KTM Komuter* services for both directions specifically based on the data of the maximum number of passengers boarding and alighting at associated rail stations/stops.

These measures could enhance the public transport agencies' ability to consider the interrelationships between different measures and the development of mathematical relationships to better understand their interactions and the effects of service attributes (Cham (2006) as mentioned in Chan (2007)). Other suggestions for improvement include increasing the response rate to both the O-D and Attitudinal surveys and the travel behavioural surveys by new internet surveys among *KTM Komuter* users, similar to on-line surveys undertaken by Grotenhuis et al. (2007), Too and Earl (2010), Filippi et al. (2013) and Khoo and Ong (2015) who have minimized the problem associated with interviewer bias. The implementation cost of this kind of survey is low but further study is needed to understand its potential bias and limitations. In the long run, it is worthwhile to re-evaluate the need for those surveys as *KTM Komuter* usage and coverage continue to increase. More innovative strategies combining automated data collection systems with targeted manual count surveys can help *KTM Komuter* service provider to estimate accurate O-D travel patterns and to assure effective cost.

The sample's socio-economic characteristics could serve as general guides when planning policies for promoting the use of the *KTM Komuter* with respect to providing high access to its service (Jain et al., 2014). The above summary of findings motivates a few additional research directions outlined in this thesis. It is clear that significant improvements in the overall performance can be achieved by careful seamless integration of service recovery strategy measures (Syahriah et al., 2008; Nor Diana, 2012). According to Grotenhuis et al. (2007), Syahriah et al. (2008) and Transportation Research Board (2013), integrated public transport information provision can relieve stress, anxiety and annoyance among waiting passengers even though it has become secondary. KL is in the midst of improving the transfer experiences in the public transport system in particular when dealing with uncertainty and time wasted in walking (transferring) and waiting (Wardman et al., 2001). Once service reliability is improved, passengers can expect related uncertainties to reduce according to the study of Wardman et al. (2001). The main conclusion that can be drawn from this research is that although the quality of both the rail stations and access-egress modes only means a minor business to *KTMB*, it also presents a challenge for planners of *KTMB* to implement it directly in the short run. Walking and its infrastructure particularly in the PTOD should be in tandem with the improvement of *KTM Komuter's* QOS specifically on station development (Koh et al., 2011). On top of that, the improvement of quality in *KTM Komuter* services can influence the demand for *KTM Komuter* services or the *KTM Komuter* ridership forecasts (Transportation Research Board, 2013) and (Cervero, 1990) as cited by Hale and Charles (2009), simultaneously affecting modal split and the move towards a more sustainable mobility (Syahriah et al., 2013).

The planning implications in this present research are consistent with an assumption of conventional travel demand models that public transport riders, particularly choice users, are mostly sensitive to a stop's service quality and fare levels. The final remark concludes that improving the quality of services of the *KTM Komuter* is important if we are to initiate positive global impacts namely in the daily transport habits of the public and the environmental effects that come with it. In addition to that, further improvement in the quality of services will increase the level of passenger satisfaction because they can continually enjoy better quality of services in the future (Rohana et al., 2012). Subsequently, Syahriah et al.'s (2013) findings indicate that the overall perception of services was convincing due to the fact that roughly 3% of the respondents opined that the services needed overall improvement and only 1% was satisfied with the improved services since the first time they used such services. This is because the 1% perceive services from the perspective of non-passengers are not familiar with them (Transportation Research Board, 2013). In view of this, the respondents negatively perceived *KTM Komuter's* overall services, result in efforts be made to improve the performance of *KTM Komuter*. Therefore, Karlaftis and Tsamboulas (2012) suggested that the performance of *KTM Komuter* be well-measured and –assessed, that profitability not be measured and progress towards achieving goals be appraised to help achieving effective strategies of business, service provision and service quality. Irfan et al. (2012) concluded that the overall findings would guide the *KTMB* management team to properly strategise and plan future operations and business. According to Filippi et al. (2013), part of these findings can be both the attitudinal and optimisation models from the previous chapters in which *KTMB* can exploit to understand patterns of user and train (travel) behaviour.

10.3 RECONCILIATION OF OPTIMISATION AND ATTITUDINAL MODELS

Attitudinal Models were produced by Attitudinal Surveys. Attitudinal Surveys here were part of the User Surveys. The User Surveys were carried out with the objective of gauging public transport passengers' response to issues relating to usage of public transport and to measure their opinions and travel behaviours. The Optimisation Models were expected to produce optimal solutions to deliberately modify the operational planning and decisions of the levels of service and overall service quality. Specifically and technically, the Optimisation Models produced optimal values of headway, number or size of fleet and vehicle capacity expected to be implemented and enforced for timetable (frequency) or schedule setting, quality rolling stock and travel time, and space comfort (Hine and Grieco, 2003) with the purpose to enhance the quality of *KTM Komuter* services and *KTM Komuter's* operational efficiency. At least, there are several important changes which need to be made in the commuter train's travel time and passengers' waiting time for the arrivals of commuter trains at the rail stations' platforms. A reconciliation of responses to these issues and results of Optimisation Models should have a substantial influence on the formulation of public transport policy or strategy recommendations. Interestingly, the reconciliation of Optimisation and Attitudinal Models can be seen from the statements in Section Number 4.4 concerning the combination of factor analysis and optimisation. Indeed, the meaning of reconciliation here involves the aspects of a methodological approach and the exploitation of major findings. These findings also offer an interesting insight on operational schemes and the effectiveness of *KTM Komuter*, an issue that has not been holistically investigated in the past. The results of this research also support the idea that regulations in the form of practice or policy should be recommended to the government. Or, the findings of this research have a number of important implications for future practices for *KTM Komuter* operator. Thus, this section discusses the future role of *KTM Komuter* and suggests regulations necessary for effectively managing and improving the quality of *KTM Komuter* services.

In designing the *KTM Komuter* Timetable, the effects of pursuing a number of different operating strategies for its services were analysed and judged against possible *KTMB's* management objectives to recommend several relevant policies that best serve each objective of the research as discussed under Section 11.1. These different policy initiatives were introduced to improve quality of *KTM Komuter* services particularly in Kuala Lumpur, Malaysia.

10.4 CONCLUSIONS

This research will be the first that studies the national commuter rail system with regard to both Operations and the inter-relationships with Non-Motorized Transport (NMT) in Malaysia. This research has explored practical and cost effective solutions that can help alleviate congestion and improve the travel experience of both Malaysian road users and KTM *Komuter* users in KL and the Klang Valley. KTMB had to redesign the patterns of service frequencies to solve longer average waiting time due to longer average running time. KTMB also needs to redesign the KTM *Komuter* system running speed. Rail transport engineers and planners, and rail capacity and analysis software are needed to primarily estimate both capacity and demand. So, fundamental problems have still to be addressed.

The links between the O-D survey analysis, the Attitudinal survey analysis and the Optimisation demonstrated by the O-D survey analysis gave information the researcher needed for the Optimisation model which determined the optimal quantity of services and the optimal fare whereas the Attitudinal survey analysis gave an indication of the importance of quality of service and how it is related to quantity.

CHAPTER 11 : MAIN CONCLUSIONS

11.1 INTRODUCTION

The following conclusions can be drawn from the present research. The methodology employed explicitly assists in identifying both the causes and their effects. Regulations should be framed and implemented immediately to improve the quality of *KTM Komuter* services. Operational efficiency along with space comfort by better managing the optimal values of headway, the optimal values of the number or size of fleets, the optimal values of the vehicle size or transit unit, TU capacity (Hine and Grieco, 2003) and strategically integrating the mode with the other public transport systems and feasible feeder bus systems should be considered too. The integration of land use and transport can promote the use of more sustainable modes of transport such as public and non-motorised transport, reduce urban sprawl, and increase integrated economic and residential activities around public transport nodes and new developing towns (Hine, 2002) within the Klang Valley. Regulations must focus on issues related to timetable setting, passengers, train and rail safety and emissions. Based on the results discussed under Section 9.3, there should be no fare setting due to the acceptable optimal prices. It is highly recommended that the existing fares be deliberately maintained for social obligations or welfare. In addition to that, safety and courtesy education and service programmes should be regularly provided by the local communities, policemen, *KTMB* and the Malaysia Institute of Transport, MITRANS of the *Universiti Teknologi MARA (UiTM)* Malaysia.

11.2 HYPOTHESES REVISITED

In section 1.5, a number of hypotheses were posited.

(i) The KTM Komuter service quality is sub-optimal in the aspect of GJT and its total weighted travel times are considerably high.

It was found that the *KTM Komuter* services do indeed have very high GJTs (between 14 minutes and 446 minutes) with a mean value that is 69.4 minutes and a standard deviation that is 55.751. The total weighted travel times (between 37 minutes and 512.9 minutes) has a mean value of 120.8 minutes and the standard deviation, 60.028. The GTC values are also very high that is between RM12.30 (£2.09) and RM4444.66 (£754.30) (mean is RM328.63 (£55.77) and standard deviation is 464.87).

(ii) KTM Komuter service quality could be improved by utilising a combination of strategies to improve the quality (levels) of service including:

(a) increasing train efficiency in terms of service frequency to reduce generalised journey time, the total weighted travel times, generalised travel cost, waiting time, in-vehicle time, passenger and potential passenger queuing and overcrowding;

(b) decreasing a train's stop time at every rail station by improving boarding/alighting time and providing convenience with wider doors and/or a few doors in addition to increasing public transport vehicles, especially rail cars/coaches or set of trains, and ensuring that loading and

waiting areas are comfortable. This is to solve issues concerning space comfort and/or passenger overcrowding on trains especially at doors during peak hours;

(c) improving soft services or skills pertaining to customer services and staff courtesy; and

(d) improving reliability or punctuality via better train schedules.

Attitudinal surveys via the KOMIQUAL models have confirmed that the *KTM Komuter* service quality could be made better by improving parking facilities, train efficiency, people services and space comfort. Issues concerning space comfort could be solved with the use of bigger size commuter trains and platforms that would ensure wider standing, loading and waiting areas for passengers comfort.

The passenger surveys have revealed that the *KTM Komuter* service quality could be improved by adjusting service frequency that might reduce GJT, the total weighted travel times, GTC, waiting time and in-vehicle time; alleviate queueing and overcrowding, enhance soft skills and reliability. The optimisation model found that service frequency should be increased over 70% and fares should be reduced by almost 10% and that this would increase patronage by over 50%. This model confirmed that both GJT and GTC were above optimal levels.

Photography shootings have demonstrated that the *KTM Komuter* service quality could be improved by reducing passenger queueing and overcrowding effectively. Train volume studies have also shown that the *KTM Komuter* service quality could be improved by adjusting service frequency.

An estimation of the number of *KTM Komuter* train sets using the ROMAN-D software to design timetables concluded that passenger density and frequency of *KTM Komuter* service can help in improving service quality. This can be done by decreasing a train's stop time at every rail station which also means improving boarding/alighting time and providing convenience with wider doors, train coaches, loading and waiting areas to reduce passenger queueing and overcrowding especially at doors, loading and at waiting areas during peak hours. Moreover, an estimation of the number of *KTM Komuter* train sets using the ROMAN-D software to design a timetable on the other hand could also improve people services and reliability thus enhancing service quality.

11.3 POLICY RECOMMENDATIONS

The relevance of these qualitative aspects (the number of passengers that have to share a bus or train, the quality of seats and the smoothness of the ride, among many others) for public transport policy is expected to increase over time (Muhammad Faishal, 2003), especially in developing countries like Malaysia because as the income of a population increases, public transport users are likely to attach more value to quality and comfort features, relative to reductions in travel time only.

Following the brief discussion on the improvement in *KTM Komuter* accessibility under Section 9.4, it is timely to propose a policy on rail accessibility for the responsibility of the government in the planning, strategising and designing of urban facilities of public transport and in defining the influence area of modes like public transport alignment as outlined in Hine (2002). Moreover, increasingly diversed trip patterns to access and egress from *KTM Komuter* stations have placed demands on more in-depth qualitative research in accessibility measurement as highlighted by Hine (2009) and renders that quantitative accessibility analysis (Hine, 2008) be included in future planning applications of travel behavioural surveys.

An early meaning of integration was derived from a discussion on urban transport policy in 1988 in the UK as 'the combination or integration of measures into a package which is balanced in its treatment of modes, areas of land use or groups of users' (May, 1993). May (1993) stated the first types of integration based on The Package Approach which ranged from integration between authorities, between different modes, between infrastructure provision, management and pricing to between transport and land use planning. However, only the last three had benefitted the most in reality. Based on the UK experience of a past series of integrated transport studies and those of May (1993) and May and Roberts (1995), highly effective integrated transport strategies would adopt the coordination of infrastructure provision, management of existing infrastructure, pricing of use of that infrastructure and telecommunications with the aid of compatible transport technology. Another meaning of integration was derived from a discussion on urban transport policy in the UK as the combination or integration of measures into a package and this is balanced in its treatment of modes, areas of land use or groups of users. In practice, both the above-mentioned terms by May and Roberts (1995) could be emphasized for the formulation of related policies in which the greatest benefits can be achieved. In the same development, one good point as highlighted by May (1993) about integration in the early 1990s was its purpose to achieve higher performance against some common strategic objectives, including efficiency in the use of resources, improved accessibility, environmental (i.e. congestion and pollution as stated in Kingham et al. (2001)) protection, safety and financial feasibility. Pertinent findings by Givoni and Rietveld (2007) and Syahriah et al. (2008) evidently underlined that connections with public transport are the most important access mode facility to the rail station, in that way accounting for a required infrastructure (i.e. goods, services and information provisions) to provide good integration between public transport and rail services. Another research evidence by Grotenhuis et al. (2007) confirmed that the integrated on-board multimodal travel information had simplified the impact of interchange by means of enabling the on-board Dutch travellers journey to be punctual at interchanges so that passengers can conveniently catch connecting modes of public transport.

From a policy perspective, this emphasizes the importance of integrated transport to achieve a shift from use of private car to travel by public transport and specifically in long distance journeys from suburban to rural areas and from rural to city areas for a complete rail network, to rail. Research by Kingham et al. (2001) drew conclusions that more than 40% of car commuting respondents desired public transport service efficiency improvements in respect to frequency, reliability, connections and convenient drop off points instead of low fares. Frequency would probably promote a modal shift to public transport commuting trips (Hine and Grieco, 2003). No more than 25% of them agreed that the less influencing factors included security, cleanliness, information and comfortable vehicles. So, these factors are termed quality of service. In the same way, this had a local empirical support of the 2010 Attitudinal surveys which reported via a question on what would be the nine reasons for *KTM Komuter* passengers to take the *KTM Komuter* as their main mode of transport for a particular personal, single trip that resulted in 32.0% of the *KTM Komuter* passengers commenting that they have no private vehicle(s) available for the trip. About 29.0% also reasoned avoiding bad traffic and 25.0% paying cheaper fares. The Users' Satisfaction surveys resulted in approximately 65.0% of the *KTM Komuter* passengers who did not own private vehicles to use this service. Roughly 54.0% of them did not want to drive private vehicles and almost 1.0% cannot drive private vehicles at all; and the importance of main and additional services, and personnel attributes particularly parking facilities, train efficiency, people services and space comfort on the *KTM Komuter* service quality were obtained by evaluating the statistical KOMIQUAL models.

This paragraph will demonstrate the role of corporate image to raise passenger trust (confidence) which in turn would raise the level of passenger satisfaction, loyalty (Chou and Kim, 2009) and willingness-to-pay (WTP). Advertising campaigns with the intent of increasing public transport usage should focus on the environmental benefits of using public transport by tailoring public transport as an environmental symbol, thus countering the car as a status symbol (Golob and Hensher, 1998) as cited by Beirão and Sarsfield Cabral (2007). Additionally, marketing campaigns should target individuals that are most motivated to experience public transport when they need it (Thogersen, 2006). This suggests the need for segmentation taking into account travel attitudes and behaviours (Lai and Chen, 2011; Daly et al., 2012; Nurul Habib and Zaman, 2012). Segmentation's real value lies in its ability to be used in the design of achievable strategies like marketing strategies thus tailoring the standards of products and services to meet passengers' expectations. Then, this useful information could help in decision-making measures (Chou and Kim, 2009). Advertisements would increase high involvement of rail passengers in terms of their needs, values, and interest in the course of rail usage (Chou and Kim, 2009; Lai and Chen, 2011). Advertising campaigns aimed at improving PT ridership should not only focus on highlighting the benefits of PT usage, its quality of service, minimum total expected costs (Abdul-Kader et al., 2010) and reasonable fares but should also focus on reducing inaccurate perceptions about PT users and emphasize the normality of PT usage (Murray et al., 2010). To enhance the important service attributes, perhaps a publicity campaign can be conducted to highlight the service functions that passengers are not familiar with (de Oña et al., 2012). Hence, *KTMB* must be aware of the effects of their market positioning on service quality perceptions.

With reference to Grotenhuis et al. (2007) and Pronello and Camusso (2011), an important supportive action should be stimulating people's attitudes through proper information and advertising to induce them to change their travel behaviour. In addition, Chowdhury et al. (2014) stressed that intelligent transport systems (ITSs) such as automatic vehicle location systems and in-vehicle real-time information can facilitate the interoperability between integrated public transport services. Public transport should be greatly supported by educational policies.

An interesting empirical evidence comes from the results of Ben-Elia and Ettema (2011) who find rewards clearly increasing the shares of public transport, cycling and working from home, apart from reducing the shares of peak-hour car driving and shifting car driving to off-peak times. This largest systematic effort to date takes into account various mediating factors such as socio-demographic characteristics, scheduling constraints and work time flexibility, habitual behaviour (Gärling and Axhausen, 2003), attitudes to commuting alternatives, the availability of travel information and even the weather. The inclusion of these factors creates a mixed discrete choice model with richer details. Therefore, the last recommendation is to implement a similar scheme (reward-based schemes in changing road commuters' behaviour related to rush-hour avoidance as empirically investigated by Ben-Elia and Ettema (2011)) onboard the rail line at certain stations with excessive peak demand.

Directions for future research are discussed in the next subheading.

11.3.1 Defining the Future Role for the *KTM Komuter*

The concept of hierarchical urban public transport system will become strategically important. Given this current condition, *KTM Komuter* has gained its own market niche. The future *KTM Komuter* lines should be connected with *KTMB*'s feeder services and integrated with other rail system services to improve accessibility, connectivity and operational efficiency with respect to level of service of the entire KL rail transport systems.

11.3.2 Innovating *KTM Komuter* Business

There are already women-only train coaches, women-only taxi-cab services and women-only bus services offered by *KTM Komuter* and *RapidKL* respectively. According to *KTMB*, 60% of their patrons are women. The women-only train coaches will make female passengers feel more comfortable, thus fulfilling their needs (posted on April 28, 2010 by The Association for the Improvement of Mass-Transit (TRANSIT), accessed on June 20, 2014). The introduction of these women-only services is mainly due to the general climate of fear among Malaysians towards robbery, pickpocketing and harassment on *KTM Komuter* trains, a lack of education about respect for women, as well as reports of violence against women which have all led to the growth of women-only services (posted on November 28, 2011 by transitmy, accessed on June 20, 2014). Creative idea as an 'innovative' approach towards solving problems from the *KTMB* should be, for example, to introduce students coaches within one set of train such as ladies' coaches and this was launched in 2010. 19.6% and 32.7% students used the *KTM Komuter* during the O-D and Attitudinal surveys in early 2010. Based on these survey results, it is worthwhile to provide this second group an exclusive service just to segregate them properly. A continual effort should be made in enhancing the quality of ladies' coaches. 63.9% and 72.7% young female passengers based on the results of O-D and Attitudinal surveys in early 2010 suggested this. Being receptive to such changes can help improve the services and business in terms of image and safety since the passengers will find services more reliable, comfortable and convenient. This provides evidence supporting the previously defined research hypothesis under Section 1.5 of ensuring that loading and waiting areas are comfortable to solve issues concerning space-comfort or passengers overcrowding on trains especially during peak hours.

11.3.3 Regulating *KTM Komuter* Services

This includes the issues of formalizing the service, providing safety and courtesy services, and controlling both staff and passenger behaviour. Socioeconomic factors must be well analysed to cater for great accessibility to *KTM Komuter* (Preston, 2001; Jain et al., 2014).

The formalization regulates the setting of fare rate. However, based on the results of the research, there should be no fare setting due to the acceptable optimal prices. It is highly recommended that the existing fares are deliberately maintained for social obligations or welfare to maximise social benefits. The existing fares are reasonably cheap or priced since 62.9 % of the *KTM Komuter* passengers during the Attitudinal surveys in 2010 rated the fare structure as good to very good. On top of that, about one third of them rated the fare structure as fair i.e. its score being 3 out of 5. However, a lower fare may result in a higher demand i.e. larger increases in passenger kilometres but similar or smaller social benefits per Malaysian Ringgit, thereby increasing the total income per day or per month for *KTMB*. The formalization also regulates the setting of timetable (service frequency), operational efficiency (quality and quantity of rolling stock and travel time), space comfort and services or systems integration (Hine and Grieco, 2003). This can be implemented and enforced by better managing the optimal values of headway, the optimal values of the number or size of fleets, the optimal values of the vehicle size or transit unit, TU capacity and strategically integrating the mode with other public transport systems and feasible feeder bus systems. These would extremely beneficial too. This also take into account the increase in the number of train coaches per train set as individually reported under Syahriah et al.'s (2013) overall findings and passengers' recommendations to improve the current services. *KTM Komuter*'s operation in 1995 and *KTMB*'s failure to plan and manage fleet size has caused the fleet size to decrease by 50%. *KTM Komuter* passenger demand, however, actually tripled (posted on December 25, 2008, accessed on July 9, 2014). Four six-car sets of *KTM Komuter* that started operations in March 2012 managed to ease the morning peak demand by accommodating an additional 32,000 passengers (Performance Management & Delivery Unit, 2011, accessed on July 9, 2014). The current condition and the likely future picture of *KTM Komuter* system requires six train coaches per train set instead of three coaches per train set. With regard to this, the respective conclusions reached from the Optimization models and the past *KTMB* surveys are that two categories of peak period for KL Inbound i.e. 0630 – 1230 and 1630 – 2130 should be designed with the shortest operating service headways at approximately 9.75 minutes and 15.25 minutes respectively whilst the early bird hour (0500 – 0630), inter-peak hours (1230 – 1630) and the remaining off peak periods (2130 – 2400) should be designed with service frequencies of 9.85 minutes, 10.75 minutes and 18.75 minutes respectively; three categories of peak period for KL Outbound i.e. 0630 – 0930, 1000 – 1300 and 1600 – 2100 should be designed with the shortest operating service headways i.e. approximately 10.75 minutes, 11.00 minutes and 9.65 minutes respectively while the early bird hour (0500 – 0630), inter-peak hours (1300 – 1600) and the remaining off peak periods (2100 – 2400) should be designed with service frequencies of 13.45 minutes, 10.05 minutes and 11.98 minutes respectively to cater to the increasing daily *KTM Komuter* passenger volume i.e. in excess of 500,000 passengers in a day. Therefore, *KTM Komuter* service for Port Klang – Sentul line should be adjusted to meet increasing demands and its service should become more frequent which will mean lower waiting times, and lesser time costs (Preston, 2010). A practical operating service headway should be 10 minutes during 0500 – 1630 hours and 15 minutes during 1630 – 2235 hours for both ways than the 2012 operation headway i.e. 15 minutes during peak hours with 37 new six-car train sets fully operational (Performance Management & Delivery Unit, 2011, accessed on July 9, 2014) and the 2010 operation headway i.e. 15 – 20 minutes during peak hours ranging from Mondays to Fridays 0500 – 0900 and 1600 – 2000 whilst from 1100 – 2000 during weekends and public holiday(s); the other nonpeak period being operated at 30 minutes. These provide supporting evidence that the previously defined research hypotheses under Section 1.5 of increasing train efficiency in terms of service frequency to reduce GJT, the total weighted travel times, generalised travel cost, waiting time, in-vehicle time, passenger and potential passenger queuing and overcrowding; and on the concluding remark of Monchambert and de Palma (2014) of improving reliability or punctuality via better train and public timetables could be justified. Monchambert and de Palma (2014) highlighted this as strategies of commuters. Other logical aspects that should be systematically regulated are passenger and train capacity, rail safety and emissions.

The other aspect for consideration is taking responsibility for, at least, integrated ticketing, not necessarily fare integration. In the passenger commuter train service, it is obvious that management is mindful of the importance of on-time service.

11.3.4 Introducing Safety and Courtesy Education and Awareness for *KTM Komuter* Passengers, Drivers, Staff and Operators

It is highly suggested that a safe driving education programme for the drivers while a safety and courtesy travelling educational and awareness campaigns for *KTM Komuter* Passengers, Drivers, Staff and Operator be introduced to resolve the low levels of safety and courtesy among the *KTMB* staff and *KTM Komuter* passengers.

Based on the sustainable transport system acceptance model developed by Khoo and Ong (2015), the most significant factors encouraging car drivers to use sustainable transport in descending order were awareness, government actions, service availability and WTP. Survey evidence by Khoo and Ong (2015) indicated that cost and service availability posed barriers for the low-education respondents to opt for sustainable transports. In recommendations, Khoo and Ong emphasised the need for increasing sustainable transport awareness campaigns like car-free day and cycling day; and creating good cycling- and walking-friendly environment so that these could improve public acceptance of a sustainable transport system in the Klang Valley.

11.3.5 Improving *KTM Komuter* first, Then Restraining Private Transport Use

It is absolutely crucial that for a successful mode shift programme, *KTM Komuter* services be improved first. The provision of a well-functioning and decent *KTM Komuter* service is required so that mode switching can be reinforced with safety benefits and not resisted by private transport users in the implementation of public transport integration measures (May, 1993; Preston, 2010). This goal would be reasonable to achieve since the 2010 Attitudinal surveys reported that nine main reasons for *KTM Komuter* passengers to take *KTM Komuter* as the main mode of transport for a particular trip from the most important to the least important which were not wanting to drive, parking woes, bad traffic, having no private vehicle(s) available, having to endure weather conditions, paying cheaper fares, having no specific reason or not being sure, experiencing a comfortable and convenient service and travelling faster. Some 32.0% of the *KTM Komuter* passengers had no private vehicle(s) available for the trip, about 29.0% reasoned avoiding bad traffic and 25.0% paying cheaper fares. Of *KTM Komuter* captive riders, 53.9% of them did not want to drive a private car. Malaysia can make an attempt to restrain the use of cars by changing the perception of the public to experience positive public rides like some European countries (Chowdhury et al., 2014), for instance, France, Germany, Britain, Netherlands; Romania, Australia, other Asian countries and Canada from the 1990s (Hine, 2000; Muhammad Faishal, 2003; Kamba et al., 2007). Based on the evidence from the interviews undertaken by Hine and Scott (2000) parking could significantly limit car users if public transport is effective and efficient. This was also supported by the conclusions of Hine et al.'s (2000) and Hine's (2009) research that Local Authority policies have emphasised public transport access to new developments and at the same time restrained car access through restriction of parking provision thus gradually deterring habitual car use. Examples of disincentives for driving are parking controls via high parking charges and limited parking bays to reduce reliance on cars and car work trips (Hine, 2002; Transportation Research Board, 2013). This means, apart from improving service frequency, quality and type of rolling stock, and travel time, space comfort, passenger and train capacity, rail safety and emissions, fare payment mechanisms must also be looked into. Such a sequenced implementation is also more politically acceptable and would thus have greater acceptance among policy makers (Malaysia Institute of Transport, 2010).

As far as Quality concepts are related to policy objectives and priority concerns, from the perspectives of the passengers and service provider, *KTM Komuter's* solutions must focus on passenger-value-oriented quality services, and must be optimal and affordable with respect to convenience, accessibility, availability, safety, frequency, reliability, comfort, flexibility and reasonable fares (Macário, 2010; Muhammad Faishal, 2003; Curl et al., 2011; Transportation Research Board, 2013; Chowdhury et al., 2014). Meanwhile, the approach by Kamba et al. (2007) was simple - results of Kamba et al.'s (2007) research revealed that both travel time and travel cost should be lowered in order to promote greater use of public transport in the KL city centre. Some recent discoveries based on the results of Chuen et al. (2014) revealed that the car is chosen as the main mode of transport by travellers in the Klang Valley because of parking charges, car and fuel prices which are affordable whilst the significant factors that will attract travellers to use rail transport range from accessibility distance to the rail stations, and transit time to time spent using the service. Among an integrated approach of global planning implications would be transport infrastructure provision and green (more environmentally friendly – less emission) modes of transport programmes (Potter and Skinner, 2000; Hine et al., 2000; Muhamad Nazri et al., 2014; Khoo and Ong, 2015), supportive land-use and transport development planning (Chowdhury et al., 2014) as done in The Netherlands, Denmark, and parts of Germany for the past decades as suggested by Forsyth and Krizek (2010) and as experienced in the UK as mentioned by Potter and Skinner (2000), Hull (2005) and Kang et al. (2014). The beginning ten year-period in the early new millennium saw demand management strategies and institutional integration mainly contributing to sustainability; and policy intervention in both private and public transports for law enforcement of education, safety, health, urban regeneration, wealth and quality of life which will then encourage a modal shift from private car to *KTM Komuter* (Hine, 2000; Potter and Skinner, 2000; Hine and Grieco, 2003; Curl et al., 2011; Preston, 2012a; Chuen et al., 2014; Muhamad Nazri et al., 2014). The latter perspective was also supported by the lessons and experience learned by most German cities (Buehler and Pucher, 2011). Further example was given by Kang et al. (2014) who stated the importance of the investment of rail infrastructure to attract passengers to accentuate the features of environmentally friendly and green transport, indicating the nature of sustainability. To integrate PT successfully, efforts need to be coordinated effectively at policy, planning and operational phases (Muhammad Faishal, 2003; Hull, 2005; Chowdhury et al., 2014).

Based on the literature review done by Muhamad Nazri et al. (2014) and research evidence of Jain et al. (2014) and Redman et al. (2013) it can be concluded that improving the quality of service would encourage people to switch to public transport although private cars remain a major personal transport in Malaysia mainly due to its affordability and reliability. Another research was undertaken by Khoo et al. (2012) as cited by Khoo and Ong (2015) regarding the significant occurrence of mode shifting from private vehicles to rail transit if the government really dictated the fuel subsidy. On the other hand, as high as 77.0% out of 66.0% of the 925 respondents were private vehicle users who would use sustainable transport options such as hybrid cars and public transport if these were considered government incentives. Rohana et al. (2012) found that the public is willing to exploit a sustainable transport system to save the environment. Khoo and Ong's (2015) surveys resulted in 86.0% and 90.0% of the respondents agreeing or strongly agreeing to opt for a public transport system and non-motorised transport, respectively if these transport services were available in their localities. Another example of the availability of public transport was based on the SP surveys of Amiruddin et al. (2012) that resulted in only 43.7% of international students opting to commute to UKM using multimodal transport. Following the above discussions, it can be concluded that *KTMB* can accomplish long-term profitability and development in their fruitful endeavours.

11.4 FURTHER WORK

It is obvious that public transport situations (travel behaviour) in many developing cities cannot be fully represented by the survey findings (Hine and Grieco, 2003). However, at least the discussions and recommendations from the results can be applied in the *KTM Komuter*-feeder bus systems.

Further research should be done to investigate the results of the Stated Preference Surveys. Stated Preference Surveys should be carried out in order to solicit the required information necessary to model mode choice behaviour. Hine et al. (2012) mentioned mode choice behaviour as the availability of alternative modes to different groups and the local availability of goods and services. These surveys are to identify the respondents' choice of preference in using a suitable mode of transport for the purpose of going to work (work trip) in town or city centres. The choice made should be on the assumption that an efficient and effective public transport service will be provided in the future. The surveys should be concurrently conducted over a few months. Face-to-face (10-15 minute) interviews should be conducted on sampled respondents at housing areas, shopping complexes, commercial areas, schools and institutions of higher learning and government offices. Results of the Stated Preference Surveys and the subsequent mode split modelling and simulations should also influence policies or strategies to be formulated.

An interesting avenue for future research would be to pursue other interaction effects between passenger-situation-staff that influence service quality evaluations at the same scenes of the survey location.

Another subject of future interest would be to conduct a study on the difficulties of access of users that do not own a car to conduct activities involving shopping, health, leisure and education, that is, to tackle the issue of social exclusion from facilities as emphasised by Hine (2008).

On the whole, the results were very encouraging even though there were insufficient samples or cases with respect to time variation and inadequate samples of survey data. The models were successful as they were able to identify the practical LOS and OSQ for *KTM Komuter* operations. However, more data is required for thorough findings. In view of data triangulation for the approach of combined factor analysis and optimisation, the researcher is encouraged to examine parking facilities, and staff courtesy and customer services if a similar research is to be carried out. The transport experiences need to be examined qualitatively and quantitatively in particular personal mobility and/or transport accessibility that would later help analyse the allocation of transport resources to achieve economic efficiency (Kamruzzaman and Hine, 2011; Karlaftis and Tsamboulas, 2012) correctly and wisely. This is an important issue for future research. Future studies on the current topics are, therefore, recommended:

A research should, therefore, concentrate on the investigation of the overcrowding model. For example, the PDFH has a guidance on realistically computing the marginal costs of carrying more passengers on existing rail cars with the consideration of overcrowding penalties to further investigate the realistic optimum price under study as highlighted at the end of Subheading 4.8.2 in Chapter 4. More detailed research is required to assess the implications of the key findings of this research for policies put forth by KTM Komuter.

11.4.1 Other research to further improve the understanding of travel patterns

Measurement methods of data collection have to be changed during the course of time. Such improved methods should have enough pre-test observations to elicit overall and general ideas and trend of the population's and transport modes' characteristics that can be evidential outcomes subsequently serving as feedback information for future passenger surveys and more concentrated analyses of O-D travel behaviour for a larger group of *KTM Komuter* users (perhaps more than 750) in a particular larger geographical catchment area and over a much longer period of time (six months or more). Further work can be done by estimating O-D matrices using mobile phone. Mobile phone data is very powerful and be extremely useful when it is complemented with traditional O-D survey methods. Such sampling can help evaluate the existing services and potential alternatives empirically.

Future extension of the present work will consider other technological advances such as video-based automatic passenger counting technology. Video cameras could be used to estimate passenger totals and to measure crowding levels as to how individuals perceive the degree of crowding, respectively at the station platforms, accessways and inside train coaches at certain railway stations from morning peak to off-peak periods during the weekdays and weekends. In the latter research, a pictorial display could depict the number of people sitting and standing in *KTM Komuter* as observed from above (i.e., a bird's eye view).

The journey time distributions of both *KTM Komuter* and *KTM Komuter* users require more study. This could be another extension of this research in respect to the analysis on in-vehicle time, user waiting time and journey time due to additional users that justify the need for better *KTM Komuter* services. The O-D and Attitudinal datasets consisted of 377 and 388 respondents, respectively. This is considered insufficient for a survey of this depth. For these reasons, there should be a sufficient number of responses or response rates based on the valid sample since the response rate for a survey administered to the general population is typically 10–40% according to Sommer and Sommer (1997) as cited by Cao (2013).

Future research investing into examining the impacts of station context on the walk access-egress distances such as that of Zhao and Deng (2013) research would provide a valuable extension of this research. Station context may consider the physical characteristics related to the stations such as station id, station function (terminal, typical or transfer), distance to city centre, road length in 400- or 800-m radius buffer of pedestrian catchment area of the rail station and number of feeder bus routes. These kinds of surveys should be carried out during various frequency service periods for seven days a week to obtain the corresponding walk access-egress patterns.

Other future research can be carried out following the study of Wibowo and Olszewski (2005) which is to incorporate the characteristics of walking route into public transport accessibility measurement (Hine, 2009) in which the walking accessibility measurement becomes more precise and comprehensive with the use of the GIS software for map calculation and presentation or tracking pedestrians' actual walking routes with on-person GPS devices as suggested by Daniels and Mulley (2013) rather than the walking distance and time. To be precise, walking effort to represent the utility of walking should be measured. The effort in the form of three walking routes i.e. walkways, sidewalks and road crossings, for example, the effort to climb one ascending step of level walking, the effort to climb one pedestrian bridge with a number of ascending steps and the effort to cross a car park or access road need to be measured for the equivalent walking distances. Such a detailed and robust accessibility measure geared to walking provides a means of forming and evaluating land use-transportation planning efforts (Hine et al., 2000). A good basis for research on measuring non-motorized accessibility can follow an example by Iacono et al. (2010) on non-motorized travel behaviour survey.

Perhaps more factors based on the new findings of related literature and research can be combined with the KOMIQUAL model to continually improve the empirical cause and effect relationship.

11.4.2 Research to enhance service performance

More research is needed to explore the effects of how crowding externality has an impact on the design process of *KTM Komuter* systems, in particular in the determination of frequencies, vehicle size and fare because these increase the marginal cost of travelling as shown in the public transport economic literature. The impact of crowding on demand and supply should be considered from the early stages of the appraisal of *KTM Komuter* projects as the design of the system and the estimation of demand and social benefits rely much on whether or not the multiple dimensions of the crowding are accounted for in the formal assessment of projects (Hensher et al., 2011; Tirachini et al., 2013).

11.5 CONCLUSIONS

The present type of research should be conducted periodically, so *KTMB* can keep track of the trends and changes in the users' social needs and perceptions to continually improve its quality and to make passengers more loyal and convinced to utilise the services extended.

This chapter summarizes the overall original contributions of the thesis which are stated below.

The generation, applications and interpretation of new knowledge was achieved through original research with the economic mathematical optimisation approaches; triangulation methods of data collection; the unique data collected, analysed, modelled and evaluated namely in the compilation of KL rail systems demand and supply data particularly the O-D Data, Attitudinal Data and the Passenger Boarding and Alighting Surveys Data set; accident data and other relevant data for supporting the research background. This permitted the estimation of percentages of modal split, travel behavioural, Attitudinal models, O-D Matrices, Generalised Journey Time and Generalised Travel Cost models, KOMIQUAL models, Optimisation models. It also led to new discoveries like the access-egress patterns pertaining to the socioeconomic characteristics of the *KTM Komuter* passengers, the degree of integration between Public Transport and Walking; and the policy recommendations based on the key findings and concluding remarks, along with indication of areas for further work.

APPENDICES

APPENDIX A

IMPROVING QUALITY OF *KTM KOMUTER* RAIL SERVICE IN KUALA LUMPUR

PLEASE TELL US ABOUT THE TRIP YOU ARE NOW MAKING. PLEASE COMPLETE ONLY A FORM AT ONE TIME. *You can make a big difference!*

Form Number: ☐

Observer/Interviewer:…………..…………...

Railway Station Name: ………………………

Day/Date/Time:……………………………..

Direction: ……………………..….

Weather:………………………….

1. WHY DID YOU (WILL YOU) TAKE *KTM KOMUTER* FOR THIS TRIP? Please check any apply and arrange ascendingly.

☐	Faster	☐	avoid bad traffic
☐	weather conditions	☐	cheaper
☐	no private vehicle(s) available	☐	parking is a problem
☐	comfortable and convenient service	☐	no specific reason or not sure
☐	do not want to drive	☐	Other(s), please state:

----

2. HOW DO YOU RATE THE PRESENT *KTM KOMUTER* SERVICES AND FACILITIES. (5: very good; 4: good; 3: fair; 2: poor and 1: very poor; please √ only one)

SERVICES AND FACILITIES	**5**	**4**	**3**	**2**	**1**
riding quality on the train					
station/stop quality (facilities, lightings…)					
Convenience					
transfer facilities (stair-climbing, escalator, cross-platform transfers)					
service frequency					
Schedules					
reliability or punctuality					
safety and security					
Aesthetics					
environmental friendliness					
comfort of train coach interior					
air-conditioning of train coaches					
cleanliness of train coaches					
Seat					
litter bin					
fully covered platform					
cleanliness of the platforms and stations					
staff courtesy					
customer services					
Fares					
number of retail outlets					
parking lots					
park-and-ride capacity					
kiss-and-ride size					
Level of crowding	**5**	**4**	**3**	**2**	**1**
availability of seats					
standing space					
Provision of	**5**	**4**	**3**	**2**	**1**
station lightings					
safety equipment					
toilets, shower and prayer rooms					
baby-changing facilities					
overhead bridge					
facilities for handicapped groups (walkways, kerb ramps like ramp to station, ramp to platform, lift, space & seat on the train coaches, jubin tactiles, special toilet & parking)					

parent(s) plus small children (waiting room, smoking zone, play ground, garden)					
Telephones					
passenger information: route time clock(real time information at stops, pre-journey information…)					
passenger information: signage and notice board					
suggestion & complaint management systems					
feeder bus services					
auto teller machines (ATM)					
Turnstile					
ticket counters					
ticket vending machines (TVM)					
electronic ticketing system: smart card, Touch n Go (TnG), etc.					
level of service (LOS)					
overall service quality					

What would be your suggestions to improve the quality of services or any other comments?...
....

3. WHAT AGE GROUP ARE YOU IN?

- [ ] less than 20
- [ ] 20 – 29
- [ ] 30 – 39
- [ ] 40 – 49
- [ ] 50 – 64
- [ ] 65 or more

4. I am

- [ ] Female
- [ ] Male

5. Nationality

- [ ] Malaysian
- [ ] Other (please specify) -----------------------------------

6. …..…PERSON/PEOPLE (OVER 15 YEARS OF AGE) LIVING IN MY HOUSEHOLD, INCLUDING MYSELF.

7. MY OCCUPATION

- [ ] student
- [ ] government staff
- [ ] private staff
- [ ] Other (please specify) ----------------------------------

8. My employment status:

- ☐ full-time
- ☐ part-time
- ☐ casual
- ☐ not at all in last 6 months
- ☐ Other (please specify) -----------------------------------

9. I am a/an

- ☐ pregnant woman
- ☐ elderly person
- ☐ teenager
- ☐ adult
- ☐ parent with small children
- ☐ disabled person
- ☐ wheelchair user
- ☐ Other (please specify) -----------------------------------

10. My monthly income (salary plus allowance) is

- ☐ under RM499
- ☐ RM500 - RM999
- ☐ RM1000 – RM1999
- ☐ RM2000 – RM2999
- ☐ RM3000 – RM3999
- ☐ RM4000 or more

Thanks so much for your help.

APPENDIX B

IMPROVING QUALITY OF *KTM KOMUTER* RAIL SERVICE IN KUALA LUMPUR

PLEASE TELL US ABOUT THE TRIP YOU ARE NOW MAKING. PLEASE COMPLETE ONLY A FORM AT ONE TIME. *You can make a big difference!* (please delete the inappropriate ones)

Form Number: [ ]

Observer/Interviewer:…………..…………...

Railway Station Name: ………………………

Day/Date/Time:……………………………..

Direction: ……………………..….

Weather:…………………………………….

1. WHERE HAVE YOU COME FROM?

………………………………………………... (full address)

Is thi your house? [ ] Yes [ ] No

Original railway station ………………………………………………...

2. HOW DID YOU GET TO THIS STATION? Please tick all modes used.

☐	walk						
☐	by bus						
☐	by express bus						
☐	by motorcycle						
☐	by taxi						
☐	by multipurpose vehicle (mpv)						
☐	by car (driver); where is car parked?	☐	car park	☐	in rail station	☐	elsewhere
☐	by car (passenger) Did the driver also ride the train?	☐	Yes	☐	No		
☐	number of accompanied persons, if any.	☐	Other(s), please specify --				

3a. HOW LONG DID YOU TAKE TO GET TO THIS STATION?…..….minutes/hours; its travel costs?RM.....……..How far from here?……….m/km;

3b. From Q2, HOW MUCH OF THIS INVOLVED walking time:……..mins.; in-vehicle time:……..mins.; transfer time [if use public transport service(s) at major transfer stations*]:……...mins.; *(*KL Sentral, KL, Bank Negara and Putra stations)*

4. WHERE ARE YOU GOING?
………………………………………………………………. (full address)

Final railway station:…………………………………..

5. AFTER LEAVING THE FINAL STATION, HOW WILL YOU GET TO YOUR FINAL DESTINATION? Please check any that apply.

☐	walk						
☐	by bus						
☐	by express bus						
☐	by motorcycle						
☐	by taxi						
☐	by multipurpose vehicle (mpv)						
☐	by car (driver); where is car parked?	☐	car park	☐	in rail station	☐	elsewhere
☐	by car (passenger) Did the driver also ride the train?	☐	Yes	☐	No		
☐	number of accompanied persons, if any.	☐	Other(s), please specify --				

6a. HOW LONG DO YOU EXPECT YOUR TRIP TO BE FROM THE STATION TO YOUR FINAL DESTINATION?....…….minutes/hours; its travel costs?RM....……..

How far from the final station?……….m/km;

6b. From Q5, HOW MUCH OF THIS INVOLVED walking time:……..mins.; in-vehicle time:……..mins.; transfer time [if use public transport service(s) at major transfer stations*]:……….mins.; *(*KL Sentral, KL, Bank Negara and Putra stations)*

7. THE MAIN PURPOSE OF THIS TRIP IS:

- [ ] to or from normal workplace
- [ ] to or from other workplace
- [ ] to or from school
- [ ] to or from college/university
- [ ] going home
- [ ] business
- [ ] personal business
- [ ] visiting friends/relatives
- [ ] recreational
- [ ] entertainment
- [ ] shopping
- [ ] Other(s), please specify

----

8. WHEN DID YOU BEGIN TO USE *KTM KOMUTER*?. year................

9. HOW OFTEN DO YOU MAKE THIS TRIP?

- [ ] 5 or more days a week
- [ ] 1 – 3 times a month
- [ ] 2 – 4 days a week
- [ ] less than once a month
- [ ] once a week
- [ ] first time have made this trip

10. HOW LONG HAVE YOU BEEN WAITING FOR THE *KTM KOMUTER*?..............minutes/hours.

11. WHAT IS THE AVERAGE AMOUNT OF TIME YOU SPEND ON THE COMMUTER TRAIN FOR YOUR TRIP?...........minutes/hours.

12. HOW MANY TRANSFERS WILL THIS TRIP REQUIRE FOR YOU TO GET TO YOUR DESTINATION?

- [ ] none
- [ ] one
- [ ] two or more

13a.WHAT CATEGORY OF FARE DID YOU (WILL YOU) PAY FOR THIS *KTM KOMUTER* RIDE?

- [ ] student
- [ ] school children
- [ ] family
- [ ] senior citizen
- [ ] handicapped persons
- [ ] delegates for study/visit/ride tour
- [ ] Other(s), please specify

13b. WHAT TYPE OF TICKETS ARE YOU USING FOR THIS TRIP?

Quantity __________________

13b. WHAT TYPE OF TICKETS ARE YOU USING FOR THIS TRIP?

☐	Adult@normal rate	☐ SINGLE		☐ RETURN		☐ WEEKLY
☐	Children of aged 4-11@half fare	☐ SINGLE		☐ RETURN		☐ WEEKLY
☐	12-trip tickets@20% discount					
☐	24-trip tickets@20% discount					
☐	Monthly season ticket@33% discount					
☐	Anywhere off-peak@RM6.00					
☐	Tour weekends & public holidays@RM10.00					

14. HOW DID YOU (WILL YOU) PAY FOR THIS *KTM KOMUTER* RIDE?

- [ ] Cash……………at counter (how much?)
- [ ] buy ticket using a ticket vending machine (TVM)
- [ ] Monthly pass
- [ ] transfer pass
- [ ] magnetic-strip tickets (Touch n Go card, MyKad*)
  *The Malaysia Government Multipurpose Smart Identity Card as e-purse
- [ ] Other(s), please specify

15.WHERE DO YOU GET INFORMATION ABOUT *KTM KOMUTER*?

- ☐ friends/relatives
- ☐ newspapers
- ☐ magazines
- ☐
- ☐ television commercial break
- ☐ advertisements at rail stations and other places
- ☐ websites of the internet
- ☐ Other(s), please specify

----

16. HOW WILL YOU RETURN FROM ADDRESS GIVEN IN Q4?......................................

If it is NOT the same transport mode, please give reason:……………………………………...……………………………………………
…………………………………………………

17a.HOW MANY PRIVATE VEHICLES ARE AVAILABLE FOR USE BY YOUR HOUSEHOLD?

- ☐ none
- ☐ one
- ☐ two or more

17b.Was a car available for this trip?

- ☐ Yes
- ☐ NO

18. WHAT AGE GROUP ARE YOU IN?

- ☐ less than 20
- ☐ 20 – 29
- ☐ 30 – 39
- ☐ 40 – 49
- ☐ 50 – 64
- ☐ 65 or more

19. I am

- ☐ Female
- ☐ Male
- ☐

20. nationality

- ☐
- ☐ Malaysian
- ☐ Other(s), please specify

- ☐

21…..…...PERSON/PEOPLE (OVER 15 YEARS OF AGE) LIVING IN MY HOUSEHOLD, INCLUDING MYSELF.

22.My occupation:

- [ ] student
- [ ] government staff
- [ ] private staff
- [ ] Other(s), please specify

23.My employment status:

- [ ] full-time
- [ ] part-time
- [ ] casual
- [ ] not at all in last 6 months
- [ ] Other(s), please specify

24.I am a/an

- [ ] pregnant woman
- [ ] parent with small children
- [ ] elderly person
- [ ] teenager
- [ ] disabled person
- [ ] wheelchair user
- [ ] Other(s), please specify

25.My monthly income (salary plus allowance) is

- [ ] under RM499
- [ ] RM500 - RM999
- [ ] RM1000 – RM1999
- [ ] RM2000 – RM2999
- [ ] RM3000 – RM3999
- [ ] RM4000 or more

Please return it to the *KTMB* staff or drop it in any survey box provided at the stations.

Thanks so much for your help.

APPENDIX C

Corridor: Port Klang-KL SENTRAL-Sentul

Day/Date/Time:…………………am/pm;

Data Recorder:………………….....................

Weather:…………………

Data Analyser:…………………………………

# of carryover passengers:………

PASSENGER BOARDING, ALIGHTING, AND ON BOARD COUNTS				
ID	RAIL STATION	ON	OFF	ON TRAIN (THROUGH GOING)

APPENDIX D

SENTUL → PEL.KLANG

NO TREN	2201	2203	2205	2207	2209	2211	2213	2215	2217	2219	2221	2223	2225	2227
SENTUL	5:05	5:15	5:25	5:35	5:45	5:55	6:05	6:15	6:25	6:35	6:45	6:55	7:05	7:15
PUTRA	5:11	5:21	5:31	5:41	5:51	6:01	6:11	6:21	6:31	6:41	6:51	7:01	7:11	7:21
BANK NEGARA	5:14	5:24	5:34	5:44	5:54	6:04	6:14	6:24	6:34	6:44	6:54	7:04	7:14	7:24
KUALA LUMPUR	5:17	5:27	5:37	5:47	5:57	6:07	6:17	6:27	6:37	6:47	6:57	7:07	7:17	7:27
KL SENTRAL	5:22	5:32	5:42	5:52	6:02	6:12	6:22	6:32	6:42	6:52	7:02	7:12	7:22	7:32
ANGKASAPURI	5:28	5:38	5:48	5:58	6:08	6:18	6:28	6:38	6:48	6:58	7:08	7:18	7:28	7:38
PANTAI DALAM	5:31	5:41	5:51	6:01	6:11	6:21	6:31	6:41	6:51	7:01	7:11	7:21	7:31	7:41
PETALING	5:34	5:44	5:54	6:04	6:14	6:24	6:34	6:44	6:54	7:04	7:14	7:24	7:34	7:44
JALAN TEMPLER	5:36	5:46	5:56	6:06	6:16	6:26	6:36	6:46	6:56	7:06	7:16	7:26	7:36	7:46
KG.DATO HARUN	5:39	5:49	5:59	6:09	6:19	6:29	6:39	6:49	6:59	7:09	7:19	7:29	7:39	7:49
SERI SETIA	5:41	5:51	6:01	6:11	6:21	6:31	6:41	6:51	7:01	7:11	7:21	7:31	7:41	7:51
SETIA JAYA	5:43	5:53	6:03	6:13	6:23	6:33	6:43	6:53	7:03	7:13	7:23	7:33	7:43	7:53
SUBANG JAYA	5:48	5:58	6:08	6:18	6:28	6:38	6:48	6:58	7:08	7:18	7:28	7:38	7:48	7:58
BATU TIGA	5:53	6:03	6:13	6:23	6:33	6:43	6:53	7:03	7:13	7:23	7:33	7:43	7:53	8:03
SHAH ALAM	5:59	6:09	6:19	6:29	6:39	6:49	6:59	7:09	7:19	7:29	7:39	7:49	7:59	8:09
PADANG JAWA	6:04	6:14	6:24	6:34	6:44	6:54	7:04	7:14	7:24	7:34	7:44	7:54	8:04	8:14
BUKIT BADAK	6:09	6:19	6:29	6:39	6:49	6:59	7:09	7:19	7:29	7:39	7:49	7:59	8:09	8:19
KLANG	6:13	6:23	6:33	6:43	6:53	7:03	7:13	7:23	7:33	7:43	7:53	8:03	8:13	8:23
TELOK PULAI	6:16	6:26	6:36	6:46	6:56	7:06	7:16	7:26	7:36	7:46	7:56	8:06	8:16	8:26
TELOK GADONG	6:19	6:29	6:39	6:49	6:59	7:09	7:19	7:29	7:39	7:49	7:59	8:09	8:19	8:29
KG RAJA UDA	6:22	6:32	6:42	6:52	7:02	7:12	7:22	7:32	7:42	7:52	8:02	8:12	8:22	8:32
JALAN KASTAM	6:26	6:36	6:46	6:56	7:06	7:16	7:26	7:36	7:46	7:56	8:06	8:16	8:26	8:36
PEL. KLANG	6:31	6:41	6:51	7:01	7:11	7:21	7:31	7:41	7:51	8:01	8:11	8:21	8:31	8:41

NO TREN	2229	2231	2233	2235	2237	2239	2241	2243	2245	2247	2249	2251	2253	2255	2257	2259
SENTUL	7:25	7:35	7:45	7:55	8:05	8:15	8:25	8:35	8:45	8:55	9:05	9:15	9:25	9:35	9:45	9:55
PUTRA	7:31	7:41	7:51	8:01	8:11	8:21	8:31	8:41	8:51	9:01	9:11	9:21	9:31	9:41	9:51	10:01
BANK NEGARA	7:34	7:44	7:54	8:04	8:14	8:24	8:34	8:44	8:54	9:04	9:14	9:24	9:34	9:44	9:54	10:04
KUALA LUMPUR	7:37	7:47	7:57	8:07	8:17	8:27	8:37	8:47	8:57	9:07	9:17	9:27	9:37	9:47	9:57	10:07
KL SENTRAL	7:42	7:52	8:02	8:12	8:22	8:32	8:42	8:52	9:02	9:12	9:22	9:32	9:42	9:52	10:02	10:12
ANGKASAPURI	7:48	7:58	8:08	8:18	8:28	8:38	8:48	8:58	9:08	9:18	9:28	9:38	9:48	9:58	10:08	10:18
PANTAI DALAM	7:51	8:01	8:11	8:21	8:31	8:41	8:51	9:01	9:11	9:21	9:31	9:41	9:51	10:01	10:11	10:21
PETALING	7:54	8:04	8:14	8:24	8:34	8:44	8:54	9:04	9:14	9:24	9:34	9:44	9:54	10:04	10:14	10:24
JALAN TEMPLER	7:56	8:06	8:16	8:26	8:36	8:46	8:56	9:06	9:16	9:26	9:36	9:46	9:56	10:06	10:16	10:26
KG.DATO HARUN	7:59	8:09	8:19	8:29	8:39	8:49	8:59	9:09	9:19	9:29	9:39	9:49	9:59	10:09	10:19	10:29
SERI SETIA	8:01	8:11	8:21	8:31	8:41	8:51	9:01	9:11	9:21	9:31	9:41	9:51	10:01	10:11	10:21	10:31
SETIA JAYA	8:03	8:13	8:23	8:33	8:43	8:53	9:03	9:13	9:23	9:33	9:43	9:53	10:03	10:13	10:23	10:33
SUBANG JAYA	8:08	8:18	8:28	8:38	8:48	8:58	9:08	9:18	9:28	9:38	9:48	9:58	10:08	10:18	10:28	10:38
BATU TIGA	8:13	8:23	8:33	8:43	8:53	9:03	9:13	9:23	9:33	9:43	9:53	10:03	10:13	10:23	10:33	10:43
SHAH ALAM	8:19	8:29	8:39	8:49	8:59	9:09	9:19	9:29	9:39	9:49	9:59	10:09	10:19	10:29	10:39	10:49
PADANG JAWA	8:24	8:34	8:44	8:54	9:04	9:14	9:24	9:34	9:44	9:54	10:04	10:14	10:24	10:34	10:44	10:54
BUKIT BADAK	8:29	8:39	8:49	8:59	9:09	9:19	9:29	9:39	9:49	9:59	10:09	10:19	10:29	10:39	10:49	10:59
KLANG	8:33	8:43	8:53	9:03	9:13	9:23	9:33	9:43	9:53	10:03	10:13	10:23	10:33	10:43	10:53	11:03
TELOK PULAI	8:36	8:46	8:56	9:06	9:16	9:26	9:36	9:46	9:56	10:06	10:16	10:26	10:36	10:46	10:56	11:06
TELOK GADONG	8:39	8:49	8:59	9:09	9:19	9:29	9:39	9:49	9:59	10:09	10:19	10:29	10:39	10:49	10:59	11:09
KG RAJA UDA	8:42	8:52	9:02	9:12	9:22	9:32	9:42	9:52	10:02	10:12	10:22	10:32	10:42	10:52	11:02	11:12
JALAN KASTAM	8:46	8:56	9:06	9:16	9:26	9:36	9:46	9:56	10:06	10:16	10:26	10:36	10:46	10:56	11:06	11:16
PEL. KLANG	8:51	9:01	9:11	9:21	9:31	9:41	9:51	10:01	10:11	10:21	10:31	10:41	10:51	11:01	11:11	11:21

Appendix D

SENTUL → PEL.KLANG

NO TREN	2421	2423	2425	2427	2429	2431	2433	2435	2437	2439	2441	2443	2445	2447	2449
SENTUL	15:05	15:15	15:25	15:35	15:45	15:55	16:05	16:15	16:25	16:35	16:50	17:05	17:20	17:35	17:50
PUTRA	15:11	15:21	15:31	15:41	15:51	16:01	16:11	16:21	16:31	16:41	16:56	17:11	17:26	17:41	17:56
BANK NEGARA	15:14	15:24	15:34	15:44	15:54	16:04	16:14	16:24	16:34	16:44	16:59	17:14	17:29	17:44	17:59
KUALA LUMPUR	15:17	15:27	15:37	15:47	15:57	16:07	16:17	16:27	16:37	16:47	17:02	17:17	17:32	17:47	18:02
KL SENTRAL	15:22	15:32	15:42	15:52	16:02	16:12	16:22	16:32	16:42	16:52	17:07	17:22	17:37	17:52	18:07
ANGKASAPURI	15:28	15:38	15:48	15:58	16:08	16:18	16:28	16:38	16:48	16:58	17:13	17:28	17:43	17:58	18:13
PANTAI DALAM	15:31	15:41	15:51	16:01	16:11	16:21	16:31	16:41	16:51	17:01	17:16	17:31	17:46	18:01	18:16
PETALING	15:34	15:44	15:54	16:04	16:14	16:24	16:34	16:44	16:54	17:04	17:19	17:34	17:49	18:04	18:19
JALAN TEMPLER	15:36	15:46	15:56	16:06	16:16	16:26	16:36	16:46	16:56	17:06	17:21	17:36	17:51	18:06	18:21
KG.DATO HARUN	15:39	15:49	15:59	16:09	16:19	16:29	16:39	16:49	16:59	17:09	17:24	17:39	17:54	18:09	18:24
SERI SETIA	15:41	15:51	16:01	16:11	16:21	16:31	16:41	16:51	17:01	17:11	17:26	17:41	17:56	18:11	18:26
SETIA JAYA	15:43	15:53	16:03	16:13	16:23	16:33	16:43	16:53	17:03	17:13	17:28	17:43	17:58	18:13	18:28
SUBANG JAYA	15:48	15:58	16:08	16:18	16:28	16:38	16:48	16:58	17:08	17:18	17:33	17:48	18:03	18:18	18:33
BATU TIGA	15:53	16:03	16:13	16:23	16:33	16:43	16:53	17:03	17:13	17:23	17:38	17:53	18:08	18:23	18:38
SHAH ALAM	15:59	16:09	16:19	16:29	16:39	16:49	16:59	17:09	17:19	17:29	17:44	17:59	18:14	18:29	18:44
PADANG JAWA	16:04	16:14	16:24	16:34	16:44	16:54	17:04	17:14	17:24	17:34	17:49	18:04	18:19	18:34	18:49
BUKIT BADAK	16:09	16:19	16:29	16:39	16:49	16:59	17:09	17:19	17:29	17:39	17:54	18:09	18:24	18:39	18:54
KLANG	16:13	16:23	16:33	16:43	16:53	17:03	17:13	17:23	17:33	17:43	17:58	18:13	18:28	18:43	18:58
TELOK PULAI	16:16	16:26	16:36	16:46	16:56	17:06	17:16	17:26	17:36	17:46	18:01	18:16	18:31	18:46	19:01
TELOK GADONG	16:19	16:29	16:39	16:49	16:59	17:09	17:19	17:29	17:39	17:49	18:04	18:19	18:34	18:49	19:04
KG RAJA UDA	16:22	16:32	16:42	16:52	17:02	17:12	17:22	17:32	17:42	17:52	18:07	18:22	18:37	18:52	19:07
JALAN KASTAM	16:26	16:36	16:46	16:56	17:06	17:16	17:26	17:36	17:46	17:56	18:11	18:26	18:41	18:56	19:11
PEL. KLANG	16:31	16:41	16:51	17:01	17:11	17:21	17:31	17:41	17:51	18:01	18:16	18:31	18:46	19:01	19:16

NO TREN	2451	2453	2455	2457	2459	2461	2463	2465	2467	2469	2471	2473	2475	2477	2479
SENTUL	18:05	18:20	18:35	18:50	19:05	19:20	19:35	19:50	20:05	20:20	20:35	20:50	21:05	21:20	21:35
PUTRA	18:11	18:26	18:41	18:56	19:11	19:26	19:41	19:56	20:11	20:26	20:41	20:56	21:11	21:26	21:41
BANK NEGARA	18:14	18:29	18:44	18:59	19:14	19:29	19:44	19:59	20:14	20:29	20:44	20:59	21:14	21:29	21:44
KUALA LUMPUR	18:17	18:32	18:47	19:02	19:17	19:32	19:47	20:02	20:17	20:32	20:47	21:02	21:17	21:32	21:47
KL SENTRAL	18:22	18:37	18:52	19:07	19:22	19:37	19:52	20:07	20:22	20:37	20:52	21:07	21:22	21:37	21:52
ANGKASAPURI	18:28	18:43	18:58	19:13	19:28	19:43	19:58	20:13	20:28	20:43	20:58	21:13	21:28	21:43	21:58
PANTAI DALAM	18:31	18:46	19:01	19:16	19:31	19:46	20:01	20:16	20:31	20:46	21:01	21:16	21:31	21:46	22:01
PETALING	18:34	18:49	19:04	19:19	19:34	19:49	20:04	20:19	20:34	20:49	21:04	21:19	21:34	21:49	22:04
JALAN TEMPLER	18:36	18:51	19:06	19:21	19:36	19:51	20:06	20:21	20:36	20:51	21:06	21:21	21:36	21:51	22:06
KG.DATO HARUN	18:39	18:54	19:09	19:24	19:39	19:54	20:09	20:24	20:39	20:54	21:09	21:24	21:39	21:54	22:09
SERI SETIA	18:41	18:56	19:11	19:26	19:41	19:56	20:11	20:26	20:41	20:56	21:11	21:26	21:41	21:56	22:11
SETIA JAYA	18:43	18:58	19:13	19:28	19:43	19:58	20:13	20:28	20:43	20:58	21:13	21:28	21:43	21:58	22:13
SUBANG JAYA	18:48	19:03	19:18	19:33	19:48	20:03	20:18	20:33	20:48	21:03	21:18	21:33	21:48	22:03	22:18
BATU TIGA	18:53	19:08	19:23	19:38	19:53	20:08	20:23	20:38	20:53	21:08	21:23	21:38	21:53	22:08	22:23
SHAH ALAM	18:59	19:14	19:29	19:44	19:59	20:14	20:29	20:44	20:59	21:14	21:29	21:44	21:59	22:14	22:29
PADANG JAWA	19:04	19:19	19:34	19:49	20:04	20:19	20:34	20:49	21:04	21:19	21:34	21:49	22:04	22:19	22:34
BUKIT BADAK	19:09	19:24	19:39	19:54	20:09	20:24	20:39	20:54	21:09	21:24	21:39	21:54	22:09	22:24	22:39
KLANG	19:13	19:28	19:43	19:58	20:13	20:28	20:43	20:58	21:13	21:28	21:43	21:58	22:13	22:28	22:43
TELOK PULAI	19:16	19:31	19:46	20:01	20:16	20:31	20:46	21:01	21:16	21:31	21:46	22:01	22:16	22:31	22:46
TELOK GADONG	19:19	19:34	19:49	20:04	20:19	20:34	20:49	21:04	21:19	21:34	21:49	22:04	22:19	22:34	22:49
KG RAJA UDA	19:22	19:37	19:52	20:07	20:22	20:37	20:52	21:07	21:22	21:37	21:52	22:07	22:22	22:37	22:52
JALAN KASTAM	19:26	19:41	19:56	20:11	20:26	20:41	20:56	21:11	21:26	21:41	21:56	22:11	22:26	22:41	22:56
PEL. KLANG	19:31	19:46	20:01	20:16	20:31	20:46	21:01	21:16	21:31	21:46	22:01	22:16	22:31	22:46	23:01

Appendix D

SENTUL → PEL.KLANG				
			0:30	
NO TREN	2481	2483	2485	2487
SENTUL	21:50	22:05	22:20	22:35
PUTRA	21:56	22:11	22:26	22:41
BANK NEGARA	21:59	22:14	22:29	22:44
KUALA LUMPUR	22:02	22:17	22:32	22:47
KL SENTRAL	22:07	22:22	22:37	22:52
ANGKASAPURI	22:13	22:28	22:43	22:58
PANTAI DALAM	22:16	22:31	22:46	23:01
PETALING	22:19	22:34	22:49	23:04
JALAN TEMPLER	22:21	22:36	22:51	23:06
KG.DATO HARUN	22:24	22:39	22:54	23:09
SERI SETIA	22:26	22:41	22:56	23:11
SETIA JAYA	22:28	22:43	22:58	23:13
SUBANG JAYA	22:33	22:48	23:03	23:18
BATU TIGA	22:38	22:53	23:08	23:23
SHAH ALAM	22:44	22:59	23:14	23:29
PADANG JAWA	22:49	23:04	23:19	23:34
BUKIT BADAK	22:54	23:09	23:24	23:39
KLANG	22:58	23:13	23:28	23:43
TELOK PULAI	23:01	23:16	23:31	23:46
TELOK GADONG	23:04	23:19	23:34	23:49
KG RAJA UDA	23:07	23:22	23:37	23:52
JALAN KASTAM	23:11	23:26	23:41	23:56
PEL. KLANG	23:16	23:31	23:46	0:01

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