IMPROVING ENERGY EFFICIENCY IN THE TRANSPORT SECTOR THROUGH SMART DEVELOPMENT

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ERIA Research Project Report 2013, No.27

Published October 2014

DISCLAIMER

This report was prepared by the Working Group for the "Study on energy efficiency improvement in the transport sector through transport improvement and smart community development in the urban area" under the Economic Research Institute for ASEAN and East Asia (ERIA) Energy Project. Members of the Working Group, who represent the participating EAS region countries, discussed and agreed to utilise certain data and methodologies to assess the efficiency improvement in transport sector. These data and methodologies may differ from those normally used in each country. Therefore, the calculated result presented here should not be viewed as official national analyses of the participating countries.

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Foreword

To cope with increasing oil demand is one of the top policy agenda in East Asia Summit (EAS) countries since it causes a variety of concerns for the countries, such as deteriorating security of oil supply, exacerbating fiscal balances, and worsening air quality.

Although a number of studies were conducted to address this issue, few were focused on an interrelation between car traffic and energy consumption. This study is unique in its approach as it will interconnect energy policy and city planning, and quantify the effects of traffic flow improvement with efficiency improvement.

The study aims to provide suggestions for policy planners in the EAS region on possible ways to improve energy efficiency in the transport sector.

I hope this study could bring new insights for those involved in this issue.

Ichiro Kutani

Leader of the Working Group

June 2014

Acknowledgements

This analysis has been implemented by a working group under the Economic Research Institute for ASEAN and East Asia (ERIA). It was a joint effort of Working Group members from the EAS Countries and The Institute of Energy Economics, Japan (IEEJ). We would like to acknowledge the support provided by everyone involved. I would like to express our gratitude especially to the members of the Working Group, ERIA; Japan International Cooperation Agency (JICA); Center for Transportation and Logistics Studies of Universitas Gadjah Mada (PUSTRAL-UGM); Toyota Motor Corporation; Toyota Info Technology Center Co., Ltd.; and IEEJ's study project team.

In addition, special notice and thanks shall be given to the author of chapters 3 and 4 of this report: for chapter 3, Arif Wismadi, Dwi Ardianta Kurniawan, Prima Romadhona, and Joewono Soemardjito, Researchers at the Center for Transportation and Logistics Studies (PUSTRAL) Universitas Gadjah Mada; for chapter 4, Takayuki Kusajima of Toyota Motor Corporation; and Akira Yoshioka, Mikio Danno, Masahiro Kuwahara, and Keiko Shimazaki of Toyota InfoTechnology Center Co., Ltd.

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List of Abbreviations and Acronyms

ASIF	= Avoid–Shift–Improve–Finance
BRT	= bus rapid transit
CBD	= central business district
CO_2	= carbon dioxide
EAS	= East Asia Summit
ERIA	= Economic Research Institute for ASEAN and East Asia
IEEJ	= The Institute for Energy Economics, Japan
JICA	= Japan International Cooperation Agency
IDR	= Indonesian rupiah
LRT	= light rail transit
MRT	= mass rapid transit
OD	= origin–destination
OECD	= Organisation for Economic Co-operation and Development
SOP	= standard operating procedure

Executive Summary

This study examines ways of improving energy efficiency in the transport sector of countries of the East Asia Summit (EAS). Among various possible measures, the study especially focuses on improving traffic flow in urban areas and on its subsequent effects.

MAIN ARGUMENT

Coping with increasing oil demand is one of the top policy agenda in EAS countries since such demand has been causing countries a variety of concerns, such as deteriorating security of oil supply, exacerbating fiscal balances, and worsening air quality. Although a number of studies were conducted to address this issue, few were focused on an interrelation between traffic flow and energy consumption. This study is unique in its approach as it interconnects energy policy and city planning, and quantifies the effect of traffic flow improvement on energy efficiency improvement.

First, the study has examined policy options that could enhance modal shift from private cars to public transport. In the second part, the study conducted a simulation analysis for a selected sample city, Jakarta of Indonesia. Based on a preference survey of the general public, this analysis figures out a possibility of modal shift which leads to reduced use of private cars and, thus, reduced oil consumption.

KEY FINDINGS

- A key element in promoting the ‘shift’ from private cars to public transport is accessibility and economic attractiveness; that is, to extend/expand the public transport network, and to make public transport tariff cheaper or increase the cost of private car ownership.

- When looking at the survey result of Jakarta, rapidness of public transport will increase its attractiveness, and thus enhance the shift

- The case study indicates that a megacity like Jakarta requires mass rapid transit (MRT) such as the metro that has dedicated lines to mitigate traffic congestion and oil consumption. However, it will take much time and funds to construct sufficient capacity of the MRT. Therefore, as a short- to mid-term measure, it is also effective in expanding the bus rapid transit (BRT) network or improve its convenience.

POLICY IMPLICATIONS

- If urban transport planning will be combined with energy policy, the country can more effectively reduce energy demand in the transport sector. This is because a part of the increase in oil demand can be explained by traffic congestion and the lack of a mass transport system.

- If a country can implement a package of comprehensive measures, one can gain more benefit than the cost of ad hoc measures. These possible policy options can be summarized in the ASIF (Avoid–Shift–Improve–Finance) framework.

- If a country can implement necessary measures in a preventive manner under long-term planning, one may be able to achieve smoother economic development. This is because policy and infrastructure development tends to fall behind an explosive increase of transport demand, and thus tends to cause chronic congestion and waste of fuel.

CHAPTER 1
Introduction

Energy demand of East Asia Summit (EAS) countries has been growing substantially, led mostly by the power and the transport sectors. Energy for the transport sector in EAS countries is dominated by oil, of which imports have been increasing rapidly as domestic production slows, causing energy supply security concerns. Meanwhile, some EAS countries subsidize oil products to ensure affordable price levels for social considerations, but this exacerbates fiscal balances. In addition, motorisation in the urban areas of some EAS countries has worsened the air quality because of increased combustion of low quality oil products. As these incidents prove, increases in transport oil demand have great socioeconomic impacts, and the improvement in efficiency for transport sector oil demand would be an important policy agenda across EAS countries.

The increase in transport sector oil demand has been led by motorisation in some EAS countries whose income level is growing rapidly. Particularly, the urban areas of rapidly growing Asia represent a higher income level than the country average, and their soaring passenger vehicle ownership has been causing a number of socioeconomic issues, including chronic traffic congestion. In fact, the average travel speed in some urban areas of Asia is slow—Jakarta at 15 kilometre per hour (km/hour), and Bangkok at 12 km/hour. This, in turn, means energy waste, time losses in economic activities, and worsening air quality.

A number of studies have been implemented to consider the energy saving potential in Asia's transport sector through the shift towards fuel-efficient vehicle units. Meanwhile, this study is unique in its approach in that it focuses on the interrelation between energy demand and traffic flow. It utilises a simulation model that would be able to analyse the impact of infrastructure development on traffic flow and the subsequent impact of the improvement of transport sector energy efficiency. The outcomes from the study would provide new insights that would contribute to the sustainable development for the cities of EAS countries with the urban transport improvement.

Rationale

The rationale of this study is derived from the 17th ECTF[1] meeting held in Phnom Penh, Cambodia on July 5, 2012. In this meeting, ERIA explained and proposed new ideas and initiatives for EAS energy cooperation as follows:

- strategic usage of coal,
- optimum electric power infrastructure,
- nuclear power safety management, and
- smart urban traffic.

The participants of the ECTF meeting exchanged views and agreed to commence the proposed new studies. As a result, the Economic Research Institute for ASEAN and East Asia (ERIA) has formulated the Working Group for the study on energy efficiency improvement in the transport sector through transport improvement and smart community development in urban areas. Members from Indonesia, Japan, Philippines, and Viet Nam are represented in the Working Group, with Mr. Ichiro Kutani of the Institute of Energy Economics, Japan (IEEJ) as the leader of the group.

Objective

This study aims to draw out policy recommendations for improving energy efficiency in the transport sector of EAS countries. Special focus is on improving the traffic flow in urban areas, particularly where population—hence, transport demand—is large, and its subsequent effect. The study consists of two different approaches—policy study and simulation analysis. Combining these two approaches is believed to bring more comprehensive results.

[1] Energy Cooperation Task Force under the Energy Minister Meeting of EAS countries.

Work Stream

First Year

(A) Selection of Model Cities

Several factors were considered in selecting Jakarta as the model city. These included city size, traffic congestion level, and data availability.

(B) Policy analysis 1

Various policies and experiences were examined and summarized into four categories, constituting the so-called ASIF (Avoid–Shift–Improve–Finance) framework.

(C) Simulation analysis 1

The model that can describe car traffic in specific area was developed. Some options to improve traffic were considered, and this cost (investment cost for road) – benefit (reduction of congestion, and thus oil consumption) was estimated.

Second Year

(D) Policy analysis 2

A policy that could enhance modal shift from private cars to public transport was executed.

(E) Simulation analysis 2

A preference survey for the general public was conducted in Jakarta to explore the driving factor in modal shift. Some options for improving the utility of public transport such as the BRT were considered, and subsequent effects (increase in BRT ridership, and thus reduction in oil consumption) estimated.

(F) Policy implications

Based on these analyses, policy implications were derived.

CHAPTER 2
An Overview of Bus Rapid Transits in the World

Introduction

Major Asian cities in the early stages of development generally suffer from chronic traffic congestion problems. The rapid income growth has spurred the mobility needs, whilst the infrastructure and capacity for public transport—rails or buses—are neither developed sufficiently nor available punctually to satisfy the growth in passenger transport demand. Lack of public transport infrastructure or service has, in turn, facilitated the growth of passenger vehicles or motorcycles, as they are the sole options that can handle mobility needs. Nevertheless, to accommodate the fast growth in economic activities, cities tend to sprawl to include the neighbouring ones from where commuters travel long, congested roads to the core business district.

As the first phase of this study identified, it is important for the rapidly growing cities of Asia to pursue the ASIF approach:

- <u>**A**void dependence on motorised transport</u> through the integration of land use planning and transport planning to create city clusters that require less mobility or reduce travel demand.
- <u>**S**hift toward public transport</u> including mass rapid transits (MRTs) and buses that can achieve lower energy/carbon dioxide (CO_2) intensities per passenger kilometre.
- <u>**I**mprove the overall transport efficiency</u> through technological innovations or policy measures to manage road traffic or use of information technology; and
- <u>**F**inance the transport-related systems</u> by reallocating the revenues from transport-related taxes to road improvement or public transport enhancement.

This phase of the study focuses on the 'Shift' toward public transport as it is the critical element toward the energy efficiency improvement in urban transport systems. The study focuses on bus rapid transits (BRTs), which can handle larger passenger capacities and theoretically can travel with faster speed compared with ordinary buses because of the provision of dedicated lanes. By taking the case of Jakarta, which has developed the BRT infrastructure, the study tries to present the current situation, identifies the benefits from the BRTs, and analyses areas for improvement.

Before presenting the discussions on the case of Jakarta, this chapter describes its benefits and costs, presents the global trends in BRTs, and analyses the two cases in Bogota and Seoul to learn the lessons.

Key Features of Bus Rapid Transits

The zest and zeal for BRTs have been maintained high in cities that are in the early stages of development. City planners of rapidly developing ones, in particular, would have to cope with the challenges of handling the increasing mobility needs before the city faces gridlock caused by traffic congestion as well as the repercussions stemming out from congestion, such as wasteful fuel use and air quality problems and their health impacts. BRTs can mitigate the congestion and its related problems since they are theoretically designed to provide (1) punctual operation on the dedicated lane; (2) faster travel speed than vehicles, buses, or motorcycles on congested roads; and (3) larger capacity to handle passengers compared with passenger vehicles or motorcycles.

Besides, the BRT is the attractive transport option for city planners as it can facilitate shifts from passenger vehicles or motorcycles with lower cost than the LRT (light rail transit) or MRT. Additionally, the BRT's attractiveness to city planners lies in its relative flexibility to change routes and add branch routes depending on the changes in demand.

Table 2-1 compares the key features of the BRT, LRT, MRT, and Suburban Rail. As shown, each transport mode has its own benefits: MRTs can serve well to carry the relative large number of passengers (more than 60,000 passengers per hour per direction) at a fast speed (30–40 km/hr). Nevertheless, its construction cost is higher than the other modes, as underground ones reach US$60 million–US$180 million per kilometre in contrast to the BRT's US$1 million–US$5 million per kilometre.

Table 2-1: Comparison of BRTs, LRTs, MRTs, and Suburban Rails

Characteristics	BRTs	LRTs	MRTs (Metro)	Suburban Rails
Segregation	At-grade	At-grade	Elevated or underground	At-grade
Space Requirement	2–4 lanes from existing road	2–3 lanes from existing road	Elevated or underground, little impact on existing road	-
Flexibility	Flexible, robust operationally	Limited flexibility, risky in financial terms	Inflexible and risky in financial terms	Inflexible
Traffic impact	Depend on policy/design	Depend on policy/design	Reduce congestion when city coverage is high	May increase congestion when frequencies are high
Para-transit integration	Straightforward with bus operations. Problematic with para transit	Often difficult	Often difficult	Usually existing
Initial cost (million US$/km)	1–5	10–30	▫ 15–30 at grade ▫ 30–75 elevated ▫ 60–180 underground	-
Practical capacity (passenger/hour /direction)	10–20,000	10–12,000 (?)	60,000 +	30,000
Operating speed (km/hr)	17–20	20	30–40	40–50+

Source: Fox (2000).

Table 2-2 shows the key characteristics of BRTs as summarised by Nakamura *et al*. (2013) in four aspects: (1) initial and operational costs, (2) passenger handling capacity, (3) construction time, and (4) infrastructure flexibility and expansibility. As shown, BRTs could be a reasonable public transport option for cities in their early stages of development because of the lower initial cost, large capacity to handle passengers, short construction time, and flexibility in changing routes and developing additional routes, depending on the changes in demand. BRTs could also be replaced by LRTs and MRTs in the future if demand increases. In other words, BRTs could serve well to facilitate shifts in mode from passenger vehicles and motorcycles at an initial stage, creating a demand basis for developing LRTs or MRTs in the long run. Meanwhile, it is important to note that the operational cost of the BRT may be higher because more drivers are needed per passenger handling capacity.

Table 2-2: Characteristics of BRTs

	Characteristics
Initial cost and operational cost	BRTs' construction cost—including land cost—is much lower than that for LRTs and MRTs. Meanwhile, operational cost, particularly drivers' cost, is higher for BRTs as these require one driver for every three cars accommodating 250 passengers (at maximum). MRTs, on the other hand, can handle more passengers with lesser staff.
Passenger handling capacity	Hourly, more than 300 BRTs could be operated at one-level crossing and in non-intersection roads. The introduction of rapid BRTs (that travel stops at major BRT stops only) could increase the number of BRTs further.
Construction time	Construction time is much shorter than that of LRTs and MRTs.
Infrastructure flexibility and expansibility	BRT lanes could be replaced by LRTs or MRTs in the future depending on changes in demand. Additionally, BRTs can flexibly change or add to its operational routes to accommodate changes in population growth or area development.

Source: Nakamura, *et al*. (2013).

Table 2-3: Differences between High-End BRT and BRT Lite

	High-End BRT/Full Service	Low-End BRT/BRT "Lite"/Moderate Service
Running ways	Exclusive transit ways, dedicated bus lanes, some grade separation, intersection treatments	Mixed traffic, modest intersection treatments
Stations/stops	Enhance shelters to large temperature-controlled transit centres	Stops, sometimes with shelter, seating, lighting and passenger information
Service design	Frequent services, integrated local and express services, time transfers	More traditional service designs
Fare collection	Off-vehicle collection, smart cards, multi-door loading	More traditional fare media
Technology	Automated Vehicle Location (AVL), passenger information systems, traffic signal preferences, vehicle docking/guidance systems	More limited technological applications

Source: Cervero (2013).

In contrast to the above two discussions comparing BRTs with MRTs or LRTs, Cervero (2013) argues that all BRTs are not the same. BRTs can be classified at least into two categories: (1) high-end BRT with full service and (2) low-end BRT with moderate service. According to this classification, the identified characteristics of BRTs in general could be applied to 'high-end BRT with full service', which distinguishes itself from 'low-end BRT with moderate service' in its provision of dedicated bus lanes, availability of frequent service, provision of shelters with fare collection system, and use of information technology such as the Automated Vehicle Location. This type of BRT offers metro quality service and is operational in Bogotá, Colombia, and Guangzhou, China.

Bus Rapid Transit Trends

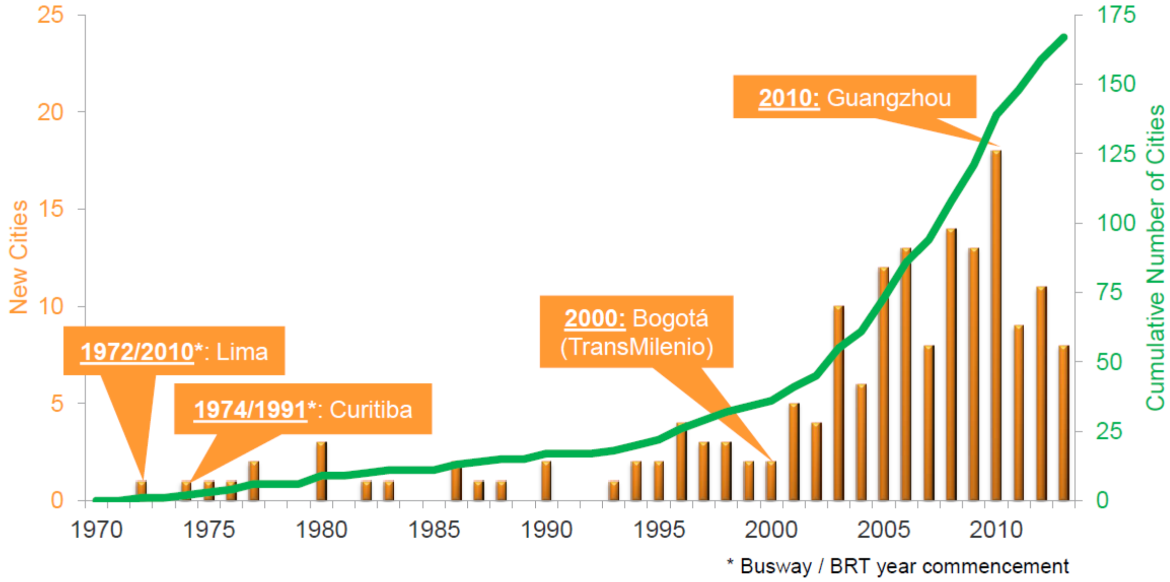
Globally, BRTs are operated in 168 cities, with a total length of 4,454 km; as many as about 31 million passengers rely on BRTs daily.[1] As Figure 2-1 shows, the number of cities that recently introduced BRTs reached its peak in 2010 when cities such as Guanghzou, Heifei, Yancheng, Zanzhuang (China), Jaipur (India), Palembang, Gorontalo, Surakata (Indonesia), Bangkok (Thailand), East London (UK), Joao Passoa (Brazil) Barranquilla, Bucaramagna (Colombia), Esado Mexico (Mexico), Lima (Peru), and Brampton (Canada) started BRT operations.

Meanwhile, the drivers behind the introduction of BRT systems differ by country and by time. Early BRT adopters such as Ottawa (Canada) and Curitiba (Brazil) in the 1970s decided to build bus ways as BRTs were developed at a lower cost compared with that of LRTs (Cervero, 1998). In recent years, cities such as Seoul (Korea) and Mexico City (Mexico) have invested in BRT systems because they consider BRTs as the public transport that can complement the existing urban rail systems (Cervero, 2013). Aside from these, in cities such as Lagos (Nigeria), Jakarta (Indonesia), and Ahmedabad (India), BRTs are intended to serve as the city's backbone of urban transport where its pre-existing private bus systems are un-integrated and para-transit services are not coordinated well with private bus services(Cervero, 2013). In Europe, small and middle-sized cities introduce buses with a high level of service (BHSL) that are operational on existing roads (without fixed lanes), whilst it is the cost-effective alternative to tramways in improving the frequency, operational hours, reliability, punctuality, journey time, comfort (including semi-sheltered bus stops), and accessibility.[2]

[1] BRTData.org

[2] DGIMTM, CERTU, CETE. 2010. *Buses with a High Level of Service (BHLS), the French Bus Rapid Transit (BRT) Concept*.

Figure 2-1: Historical Trend in the Number of New BRTs



Source: BRTData.org

Then which regions and countries in the world have adopted BRTs? Regionally, Latin America tops the world in the number of cities that introduced BRT systems, reaching 56 in total by the latest figure (May, 2014), representing 33 percent of the world total. This is followed by Europe at 43 cities, Asia at 35 cities, and North America at 24 cities. The number of cities in Oceania and Africa that introduced the BRT is respectively 7 and 3—relatively small compared with the other regions.

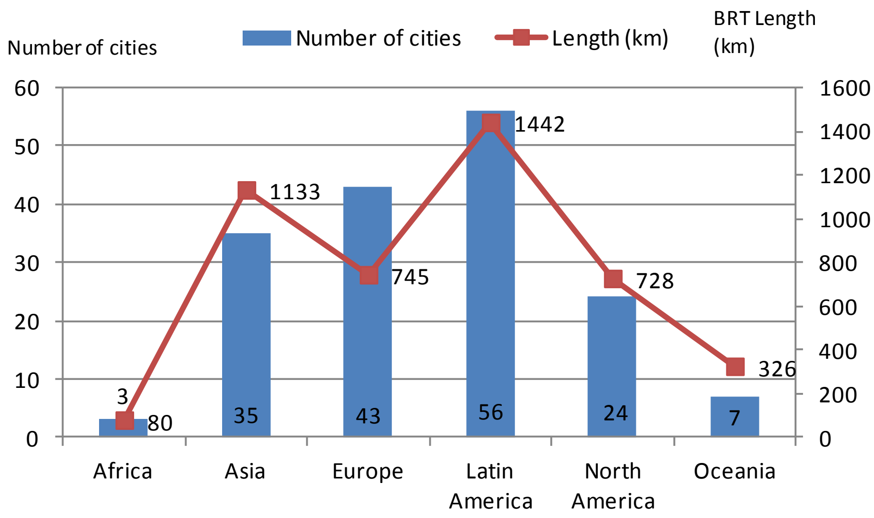
As Figure 2-3 shows, by country, Brazil leads the world in the number of cities (32) which adopted the BRT. It is followed by China (18 cities), the USA (17 cities), France (13 cities) and the UK (11 cities) using the latest figure at the time of writing.[3] Aside from the number of cities, Brazil leads the world in the number of passengers per day (11.9 million per day) and total BRTs' route length (682 km). The driving factor behind Brazil's becoming a global leader in BRT is exemplified by Curitiba, the first city in Brazil to introduce BRT systems and is spreading the experiences to other Brazilian cities. Curitiba's urban master plan that it has had since 1968 integrates public transport with land use planning. In fact, the BRT system started its operation in 1976 as the cost-effective public transport option—compared with the

[3] BRTData.org

metro system in Sao Paulo—that can provide exclusive right-of-way, sheltered stations, and frequent and fast service. It is best known for its restriction of urban growth along the key transport routes; buildings are allowed only along bus routes.[4] As a result of integrating urban transport as the core element of land use planning, currently no one in Curitiba lives more than 400 metres away from a bus (and minibus) stop.[5]

China's BRT systems follow those of Latin America with the introduction of dedicated right-of-way, sheltered stations, and frequent/punctual service. The outstanding cases of BRT systems in China include Guangzhou (38,300), Langzhou (15,500), and Zhengzhou (21,600), where the number of passengers per day per route kilometre is more than 10,000.

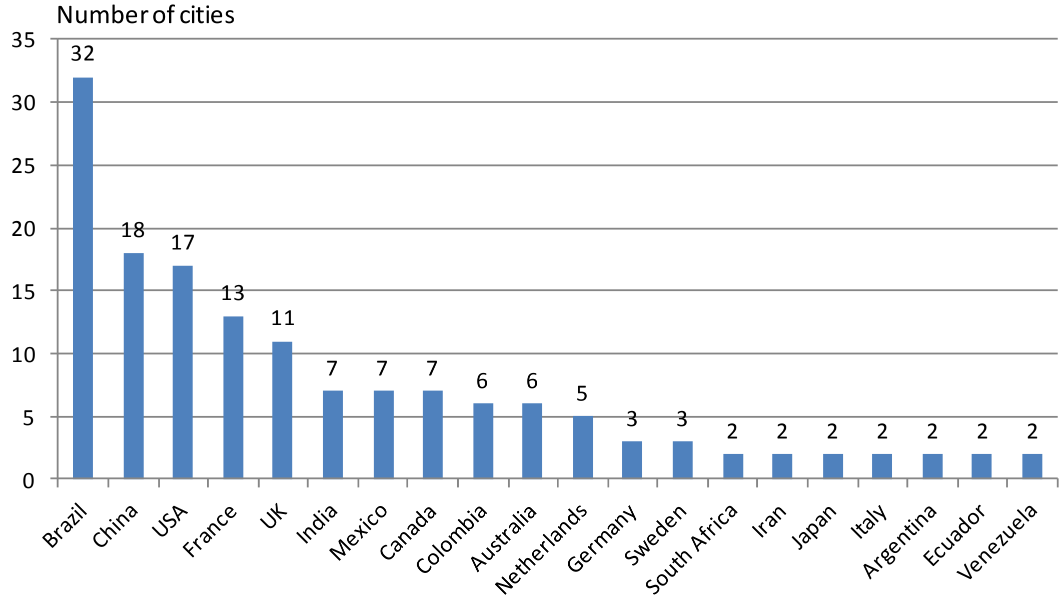
Figure 2-2: Number of Cities with BRTs (per region) and BRT Length (km)



Source: BRTData.org

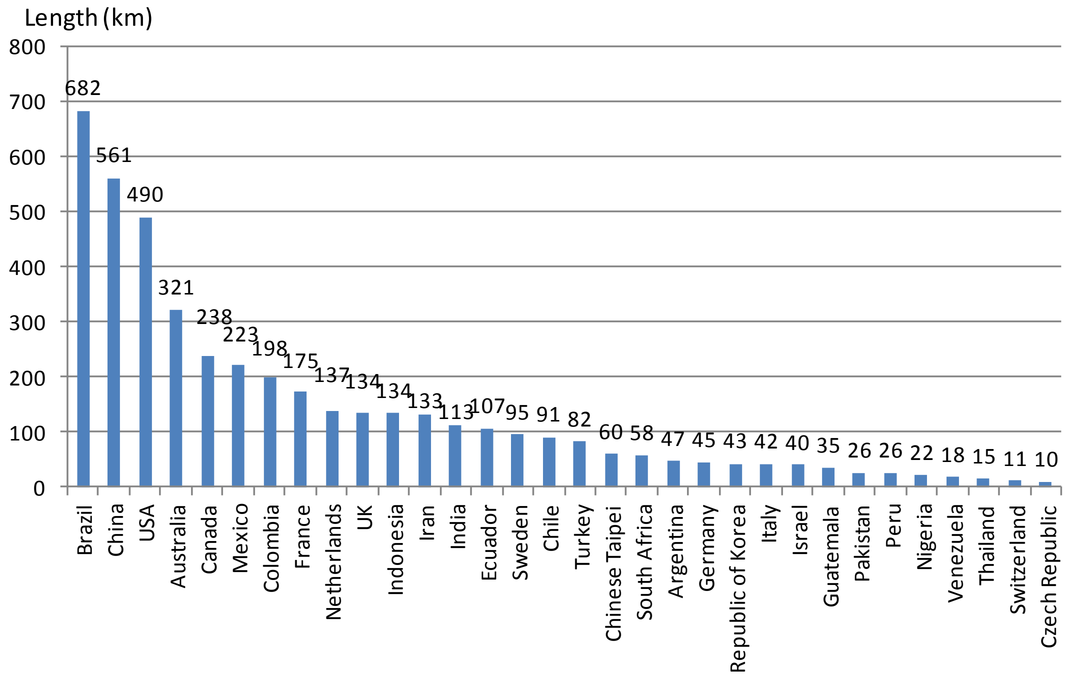
[4] BBC. *Case study: the BRT in Curitiba. Geography – Sustainable Living.*
[5] Ibid.

Figure 2-3: Number of BRTs, by country



Note: The cities with one BRT operational line are excluded from the figure.
Source: BRTData.org

Figure 2-4: BRTs' Length, by country



Source: BRTData.org

It is important to note that among the top five countries in terms of the number of cities that adopted the BRT, the types of general BRTs differ between emerging countries and developed ones. As previously described, BRTs of emerging members such as Brazil and China are generally the high-end type, being operated on dedicated right-of-way lanes. In contrast, BRTs in the USA, France, and the United Kingdom are the combination of high-end BRT and BRT-Lite systems, the latter of which does not have fixed operational lanes. The difference in terms of BRT types, operational aspects (such as frequency, coordination with para transits, including mini buses), and urban settings (such as the location of work area, and its distance from residential area, and urban population densities) explain the difference in the number of daily passengers among the top five countries with BRTs as shown in Table 2-4.

Table 2-4: BRTs in Brazil, China, the USA, France, and the UK

Countries	Passengers per day	Number of cities	Length (km)	Passengers per day per km
Brazil	11,962,888	32	682	17,541
China	3,978,250	18	561	7,091
USA	360,969	17	490	737
France	381,900	13	175	2,182
UK	162,429	11	134	1,212

Note :UK = United Kingdom, USA = United States of America.
Source: BRTData.org

Cases of Bus Rapid Transits

Bogota

TransMilenio in Bogota[6] (Colombia) offers the outstanding example that the city's BRT systems—in coordination with feeder bus systems—could facilitate shifts away from passenger vehicles and minimize congestion as well as transport-related air quality problems. The city's BRT undertakings

[6] Bogota has an urban population of 6.77 million at an area of 1,587 km^2.

and achievements offer good examples for other cities in the early stages of development to follow. In fact, experts from TransMilenio were invited to Jakarta and contributed to the creation Jakarta's TransJakarta.

Before the introduction of BRTs in 2002–2003, Bogota suffered heavy congestion and air pollution problems resulting from the exhaust fumes from old buses. Data show that by 1994, the city had 22,000 units of small and old buses that were at least 14 years old; these buses were controlled by more than 60 loosely formed 'companies' or 'associations'.[7] The operations of these bus companies were not coordinated to have required passenger journey time, the average of which was one hour and 10 minutes, and the passenger vehicles occupied 95 percent of the road space for handling 19 percent of motorised trips. These posed obstacles for the buses' fast operation.[8]

Assisted by the Japan International Cooperation Agency (JICA), Bogota has developed an urban transport master plan that delineated the handling of urban transport demand with the provision of bus-based trunk line. A feasibility study was implemented in 1998, along with the regulation of vehicle numbers controlled by plate numbers during the peak hours, and upgrades and realignment of pedestrian areas—all of which efforts culminated in the introduction of BRT systems in 2000.[9]

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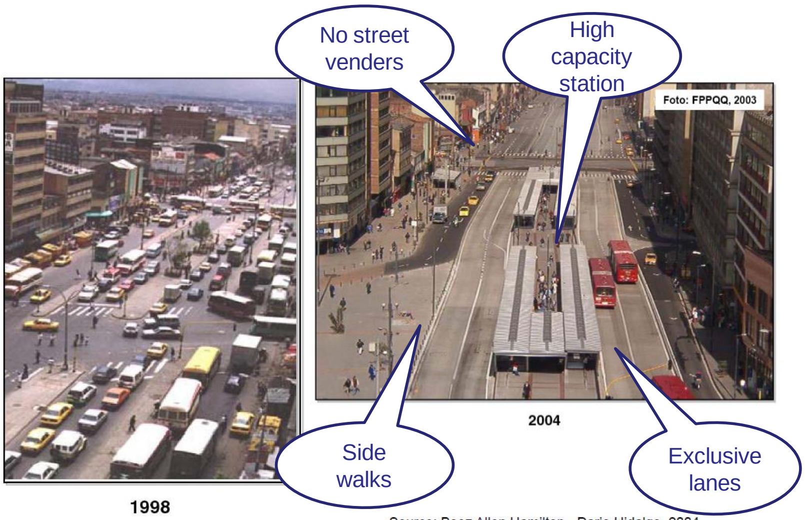
[7] Asian Development Bank and Ministry of Urban Development, *BRT – Case Study 2. Bus Rapid Transit (BRT): Toolkit for Feasibility Studies*, http://sti-india-uttoolkit.adb.org/index.html (accessed on May 19, 2014).

[8] Ibid.

[9] EST portal site (in Japanese), http://www.estfukyu.jp/estdb6.html

Figure 2-5: Bogota's Transport System Reform: Before and After

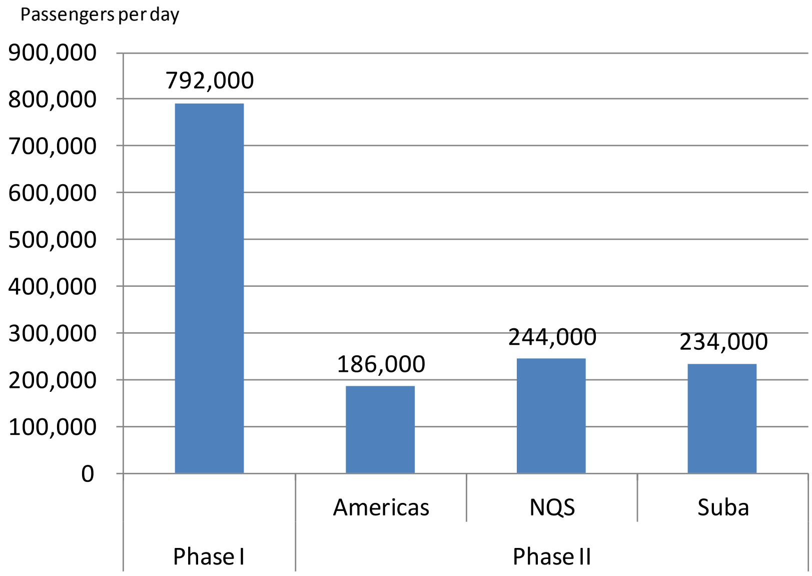


Source: Booz Allen Hamilton - Dario Hidalgo, 2004.

In Bogota, the BRT system was developed in phases, with the initial phase being implemented in 2002–2003, the second phase in 2005, and the third phase currently under the planning stage, with the aim for the whole system to cover 95 percent of the urban area. The initial phase comprises three trunk lines, with a total length of 42 km, and seven feeder routes totalling 346 km. The second phase comprises 43 km of three trunk corridors. Figure 2-5 compares the street before and after the introduction of the BRT system whose major trunk lines have two dedicated lanes in each direction and a high-capacity-sheltered station. Aside from the mere introduction of BRT systems as the trunk line, the supporting measures should be effectively taken to eliminate street vendors and provide pedestrian sidewalks.

TransMilenio S.A. was established in 2000 as a state stock company responsible for planning, management, and operation. A main objective of the TransMilenio establishment was to reorganise the operation of buses amounting to 30,000–35,000, and to reduce the numbers of buses in the corridor (Hook, 2005).

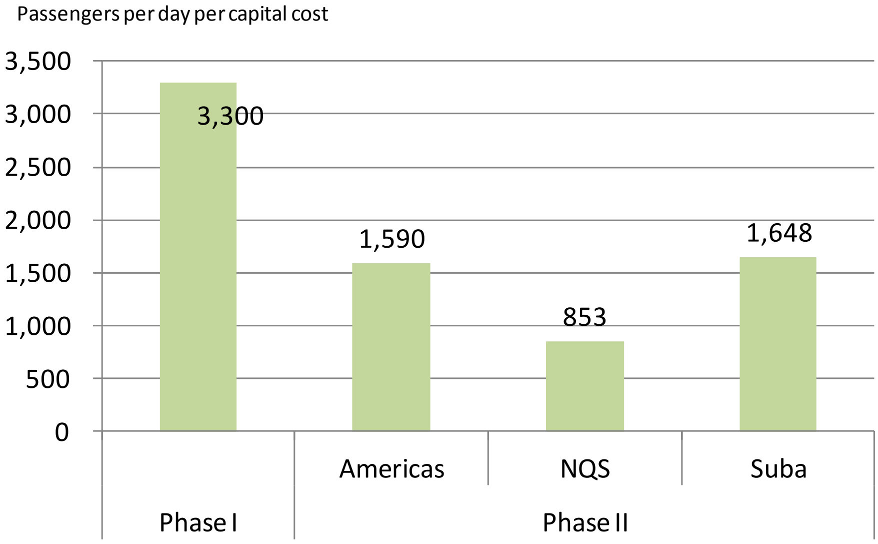
Figure 2-6: Number of Passengers, per day



Source: Dario Hidalgo, TransMilenio-Booz Allen Hamilton, 2004

The TransMilenio successfully attracted passengers. The number of daily passengers differs by the phase of development, reflecting the difference in length and operational areas (Figure 2-6). Phase I–developed–trunk line performs well to attract nearly 800,000 passengers daily, and its per capital cost performance represents the highest as well, representing 3,300 passengers (Figure 2-7). It has also successfully increased the share of BRTs in the entire modal split, representing 62 percent in 2008 (Figure 2-8).

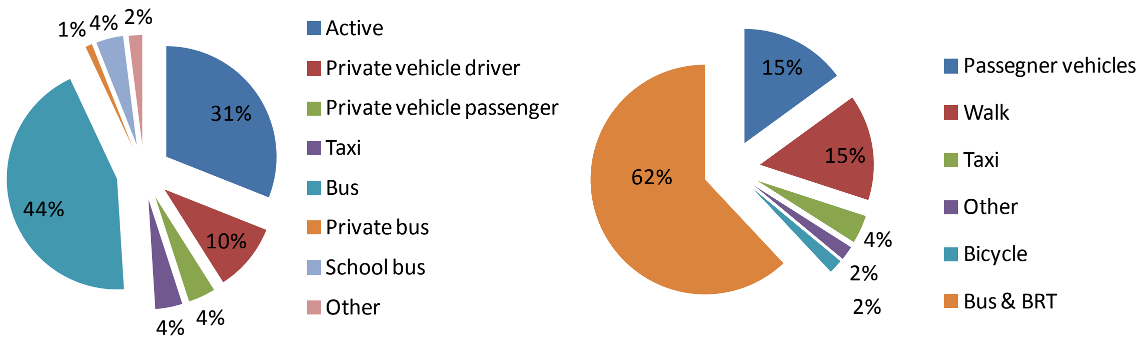
Figure 2-7: Number of Passengers, per day per capital cost



Note :NQS = Avenida Norte-Quito-Sur, an arterial road in Bogota, Colombia.

Source: Dario Hidalgo, TransMilenio-Booz Allen Hamilton, 2004.

Figure 2-8: Modal Share (left – 1999, right – 2008)



Source: Mayor of Bogota – TransMilenio S.A. and travel survey Bogota region 2008.

The key element in TransMilenio's success that is widely accepted globally rests on financial sustainability. Public funds were provided to develop the infrastructure for exclusive bus lanes, sheltered bus stations, terminals, control centre, and the sidewalks and bicycle paths, whilst no operational subsidies are provided since the system implements means for maximising profits.[10]

For meeting the profit maximisation objective, TransMilenio considered it important to estimate passenger demand, and invested US$1 million in traffic demand modelling and planning. Accurate demand estimates could provide a basis for engineers to develop the system that can efficiently handle the traffic demand, whilst it could also provide reference for TransMilenio to negotiate with the private trunk-line operators, and decide their travel kilometre. Additionally the traffic demand modelling results were utilised to estimate bus fare; it was at US$0.40.

The trunk line is operated by four different private companies that originate from local transport companies, invested by international companies. They are supposed to share the commercial risks, including passenger demand (Hidalgo, 2008). Trunk-line operators are essentially paid by the travel distance (bus kilometre); nevertheless, if the demand is lower than projected, TransMilenio has the right to reduce the trunk-line operators' travel distance.

[10] Ibid.

Meanwhile, a 10-year concession contract could be extended if the demand is lower than projected so the originally estimated demand can be achieved. This way trunk-line operators have incentives to improve their service quality so they can attract enough ridership within shorter bank loan payback period for buses' rolling stock, if any (Hook, 2005).

Another important feature contributing to the financial sustainability of TransMilenio is its fare collection system. The fares are not directly collected by the trunk-line operating companies; these are collected by a separate company using smart cards. Revenues are initially stored in a trust fund, managed by a financial service provider, and distributed to the participating companies. This way TransMilenio ensures fairness among the participating private companies.

Seoul

In 2004, the then city mayor (later President of Korea) Myun-Bak Lee implemented the urban transport reform, focussing on bus reforms and integration of the fare collection system among buses, rails, and subways. This reform provides a good example for other Asian cities to follow due to the innovative measures taken to reduce traffic congestion and improve the overall efficiency of urban transport systems.

Before the reform, nevertheless, bus services in Seoul were operated by a number of private companies whose operations—in terms of routes, schedules, or other services—were uncoordinated. The Seoul metropolitan government was responsible only for determining fares (Pucher, *et al.*,2005). Because the operational routes were not coordinated, buses competed at the profitable routes, provided passengers with poor service quality, and frequently caused accidents. Such poor service quality deteriorated the city dwellers' confidence in buses, increased reliance on passenger vehicles, worsened congestion, and increased illegal parking and accidents. Of course, these factors resulted in air quality problems and wasteful energy use.

The Seoul metropolitan government adopted the following measures to reform the public transport sector:

- **Reorganisation of bus routes**

  Buses were reorganised into (1) trunk-line buses, (2) metropolitan trunk-line buses, (3) general branch-line buses, and (4) circular branch-line buses. Trunk-line buses are painted in blue, and run along major trunk roads or between city outskirts and central business districts (CBDs). Metropolitan buses are red, and run between the areas beyond the city border and CBDs. General branch route buses (in green) operate to enhance connections between trunk route buses and rails. And circular buses are operated within the CBD (Ministry of Land, Infrastructure and Transport, and the Korea Transport Institute, 2013).

- **Quasi-public operation system of bus companies**

  Private companies operate on the four types of routes specified above, whilst the Seoul metropolitan government determines fare price, schedule, and routes. It also collects the fares, and distributes the revenues to private bus companies based on bus kilometre travelled instead of passenger kilometre in the attempt to improve bus service quality. Those bus companies that cannot collect enough fares to cover the operational cost are compensated through municipal subsidies. This way the operation of bus service has a quasi-public nature that incentivizes private companies to improve the service quality rather than to be competitive to grasp passengers or to drive recklessly.

- **Automated fare collection system using smart cards and fare integration**

  Public transport fares, including those of buses, rails, and subways, are integrated so that the passengers are charged with the travel distance. Fares are automatically collected using smart cards called T-money. Using T-money, passengers who transfer between buses and rails/subways can enjoy some discounts.

- **Improvement in bus operation**

  Bus operations at the trunk road have been improved as buses can use median bus lanes, which can avoid traffic congestion. The Bus

Management System is introduced to understand real-time bus operation, using GPS (global positioning system); the control centre provides information on traffic conditions and instructions on route change or adjustment on distance with other buses on the lane.

Data show clearly that the public transport reform was successfully improving the service quality of buses and public transport. Table 2-5 compares several indicators between 2003 and 2005 that show how the reform helped improve public transport services and contributed to cost savings. Indicators such as buses' operational speed clarify the impacts of mitigating congestion to increase the speed to 22 km/hour from 16.7 km/hour. The number of accidents was reduced from 659 to 493 in 2005. Meanwhile, the modal share of public transport, including both buses and rails, did not substantially change immediately after the public transport reform, whilst the impacts are felt long term.

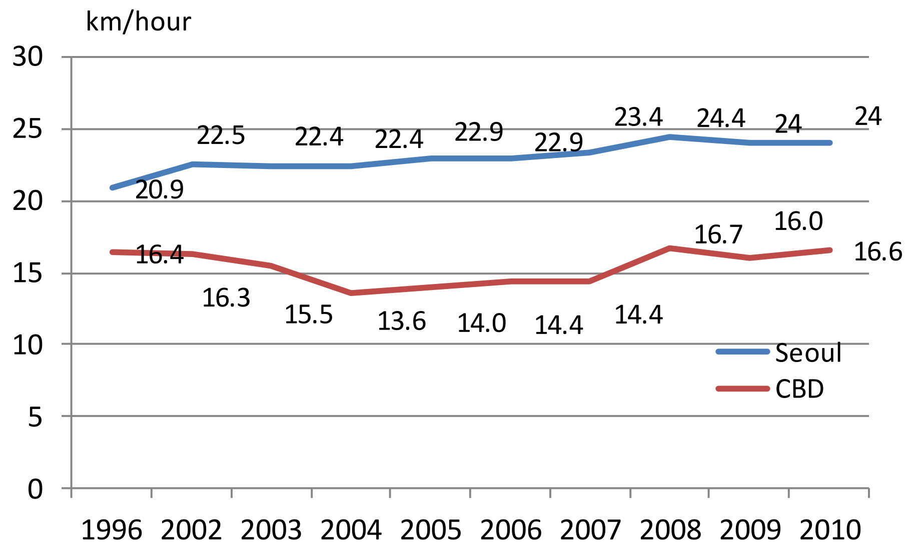
Table 2-5: Achievement Indicators of Seoul Buses (2003 and 2005)

Categories	Achievement Indicators	Goal Achievement Rates
Bus speed	Operational speed (km/hour)	16.7 → 22.0
Service supply	Operational rate (%)	82.5 → 96.4
Operational safety	Accidents (number)	659 → 493
Punctuality	Distribution of operational interval	0.69 → 0.56
Affordable fares	Fare per trip (KRW)	620 → 592
Revenue transparency	Card usage rate (%)	77.4 → 88.9
Shifts to public transport	Modal split (%)	61.2 → 62.3

Air quality improvement	PM10	69 → 61
	CO	0.7 → 0.6
Cost reduction	Travel cost savings benefit	Savings of about 225.1 billion won

Source: Seoul Metropolitan Government (2006).

Figure 2-9: Travel Speed of Passenger Vehicles in Seoul and CBD (1996–2010)

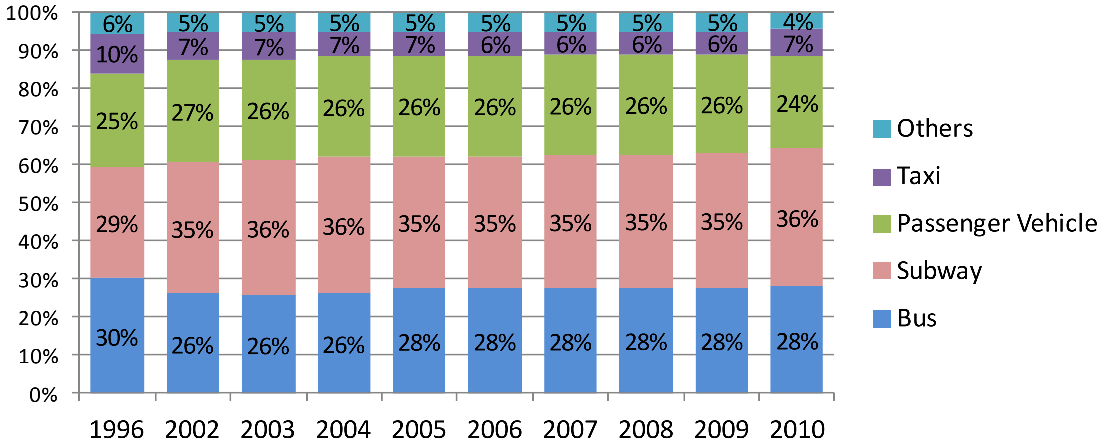


Note :CBD = central business district.
Source: Seoul City Transport Bureau homepage http://traffic.seoul.go.kr/archives/285

Figure 2-10 shows the travel speed of passenger vehicles in Seoul and CBD (1996–2010). The average speed in Seoul has increased from 20.9 km/hour in 1996 to 24.0 km/hour in 2010, whilst that in the CBD did not improve until 2007, representing 14.4 km/hour in contrast to 16.4 km/hour in 1996. It started improving from 2008 onwards, which should be caused by reduced traffic volume resulting from higher gasoline/diesel prices due to the rise in the international crude oil price levels.

Figure 2-11 shows the modal share in Seoul from 1996 to 2010. Although the bus share dropped from 30 percent in 1996 to 26 percent in 2002, it recovered to reach 28 percent in 2010 at the expense of decreased share of passenger vehicles. Easier transfer from buses to buses or subways to buses, using the smart card system, contributed to the increases in bus share among all the modal choices.

Figure 2-10: Modal Share in Seoul (1996–2010)



Source: Seoul City Transport Bureau homepage http://traffic.seoul.go.kr/archives/285

Issues and Implications

BRTs are the attractive transport option for city planners as these can facilitate shifts from passenger vehicles or motorcycles with lower cost to LRTs or MRTs. Additionally, the BRTs' attractiveness to city planners lies in its relative flexibility in changing routes and adding branch routes, depending on the changes in demand. Nevertheless, the success of BRTs depend on various factors, including system operation, fare collection, and integration with the other trunk-line rail, subway systems, and feeder buses. BRTs alone cannot be the solution to cope with urban transport–related issues, of course.

In the case of Bogota, despite the global praise over the outstanding performance and achievements of BRT systems, protest against the TransMilenio took place in 2008 and 2012 due to the increased dissatisfaction with the BRT systems caused by overcrowded buses, low frequencies, lack of alternative public transport options, and high fare. Seoul's public transport reform has successfully increased the modal share of public transport, and it has greatly improved bus service quality. Nevertheless, financial sustainability on the bus system operation remains to be an issue. In fact, the poor financial performance of bus companies is supplemented by municipal subsidies, and the fiscal burden has been increasing with time. For instance, in 2009, the subsidies provided to the bus companies by the Seoul municipal government reached 664.3 billion Korean won, accounting for 16 percent of transport-related budget. And such subsidies are increasing at above 10 percent per year (Shimoda and Shimizu, 2013).

Ultimately, BRTs could serve as the intermediate transport option that can create the basis for framing city dwellers' lifestyle towards shifting away from passenger vehicle dependence with due considerations for its infrastructure, frequency, punctuality, service quality, and connection with feeder buses and other trunk-line rails. Meanwhile, it could serve as the intermediate public transport option for the 'megacities' at the early stages of development before full-fledged public transport infrastructure—including subways, rails, and connection with bus systems—are in place. In other words, cities need to formulate a long-term plan on how to manage the rising mobility needs with the provision of public transport infrastructure, in steady cooperation and coordination with relevant local and national organisations.

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CHAPTER 3
Case Study: Preference Survey in Jakarta

Introduction

Some major cities of the Association of Southeast Asian Nations (ASEAN), except Singapore, are still facing the challenge of improving the public transport services and their modal share. In emerging ASEAN countries, public transport operators and government authorities have been facing sizeable challenges in providing public transport for commuters. They need to improve their transport infrastructure and the reliability of services, which will help boost commuter satisfaction (Accenture Research Sreejith Sreedharan, 2013).

Since the latter half of last century, Asian cities have experienced rapid economic development and urbanisation resulting in a significant increase in the mobility of people and goods that are highly dependent on automobile. Most major Asian cities have exhibited a high rate of increase in car ownership. Capital cities especially in the ASEAN countries experienced the highest increase in car ownerships (Hayashi, *et al.* 2004). Only very few examples such as Singapore—which represents a success story in urban transport policy implementation in the Asian and ASEAN contexts—have formulated the policy and objective of making public transport a choice mode by setting the target of 85 percent of commuters having completed their door-to-door journey within 60 minutes during peak hours through improved transfers and priority (GIZ, 2011).

In Asian countries, shifting towards public transport (bus, trams, and rickshaws) has been experienced since 1900 but non-motorised transports were still dominant. People started to move to individual mobility, first two wheels and then four wheels, from 1945 to 1975. From 1990 to 2005, the explosion of public demand for individual mobility has overtaken public transport. And since 2005, the re-emerging interest in public transport has been regarded as an effective policy to improve people's willingness to utilise public transport (Huizenga, *et al.*, 2006).

Whilst governments are increasingly active as regards air pollution and reducing the energy used by the transport sector, there is often a large gap between the technology available and best practice know-how, the networks necessary to build consensus, and the actual implementation of transformative change. The United Nations Environment Programme (UNEP) employs a threefold strategy to address externalities from road transport; namely, Avoid–Shift–Improve. By designing these three pillars, the UNEP strategy is ensuring: (1) reduced and avoided demand for emission-intensive transport modes whilst facilitating the increased mobility of people, goods, and information and ensuring that efficient transport is devised around smart infrastructure and mobility planning; (2) a shift from more energy-intensive and environmentally harmful modes of transport to less-polluting and more efficient modes (public transport and non-motorised transport); and (3) reduced impact on energy consumption and environment through improved, cleaner transport technology and policy solutions.[1]

This approach has been extended to support the sustainable transportation development in terms of energy efficiency by including finance in the strategy, ASIF (Avoid–Shift–Improve–Finance) (ADB, 2009). ASIF is also an effective approach in mitigating CO_2 in urban transportation (Schipper, 2009). In the case of Indonesia, the government has encouraged the modal shift as an effective strategy to satisfying each citizen's remaining transport needs using the most environment-friendly modes possible as stated in the Indonesian Climate Change Sectoral Roadmap (ICSSR) (BAPPENAS, 2010).

In Indonesia, the BAPPENAS (National Development Planning Agency) has formulated the shift programme through 'pull' measures (Travel Demand Management). The Government of Indonesia planned to strengthen the public transport improvement programme by attracting people to public transport and, hence, reducing the use of private cars. The implementation of BRT in 10 cities in Indonesia is one of the programme realizations(BAPPENAS, 2010).

[1] http://www.unep.org/Transport/About.asp

The share of the BRT, especially in Jakarta which represents urban public transport performance in Indonesia, however, still remains low (ERIA Study Team, 2010). Efforts to attract people to use the public transport (BRT) should be continually carried out. If no attempt is made to this direction, the system would not be able to compete with the high motorisation rate.

Attempts to shift from private to public transport in some cities with BRT implementation in Indonesia have not yielded significant results. BRT service is not yet a public choice mode because the BRT is still less attractive compared to private motorised vehicles. Therefore, the key making the shift towards public transport service successful is how to make BRT more attractive than private vehicles.

Among many factors to shift, travel time from origin to destination, requirement for transfer between routes, and comfort during transfer have been recognized as possible variables which influence the preference to use the BRT. However, the magnitude of those variables is not really measured in order to push forward the shift. Understanding the magnitude to shift will help decision makers set reasonable policies and their implementation instruments.

To illustrate how a reasonable policy could be addressed with certain implementation instruments, a case study in Jakarta was conducted. As a representative of Indonesian and ASEAN cities, Jakarta has been facing problems of high motorisation rate, congestion, and worsening air quality. Since the last decade, the number of commuters to Jakarta has been increasing dramatically to 1.5 times as many as that of 2002. Commuters have changed their transport mode, thus the increase in cars and motorcycles (more than 50 percent). However, the share of bus users in commuters was approximately 40 percent in 2002 and declined to approximately less than 20 percent in 2010 (Coordinating Ministry of Economic Affairs, Republic of Indonesia, 2012). To address this problem in the transport sector, the government has targeted the share of urban public transport in the Great Jakarta area to about 30 percent in 2015, 34 percent in 2020, and 36 percent in 2030.[2] These policy targets are considered ambitious and need to be

[2] Rencana Induk Transportasi Perkotaan Jabodetabek (SITRAMP), 2003.

confronted with the possible means and instruments to attract public transport.

The general objective of this chapter is therefore to confirm whether BRT service improvement could achieve the targeted modal share in the policy document. Moreover, there are two specific objectives: (1) to find the possible intervention to achieve the targeted modal share of public transport, and (2) to generate a utility function of modal shift applicable for transport modelling, which is required in predicting modal shift.

To find the answer, a hypothetical improvement of BRT services in Jakarta was offered to car users in a stated preference survey. Three implementation strategies were offered to improve the service: (1) direct service with less stops and transfers between origin and destination, (2) improved infrastructure to allow BRT priority with faster cruise speed than regular service, and (3) improved standard operating procedure (SOP) to reduce transfer time. Based on this implementation instrument, a stated preference survey was conducted with three choice sets: (1) reduced travel time, (2) reduced number of transfers, and (3) time to transfer. The survey was conducted in BRT (TransJakarta) Corridor 3 (route Kalideres – the central of Jakarta). Two groups of respondents consisted of existing BRT users and commuters who live in the Tangerang city area. Total respondents were 240, 60 of whom were existing BRT users and 180 respondents were commuters.

Material and Method

Approach for Simulation

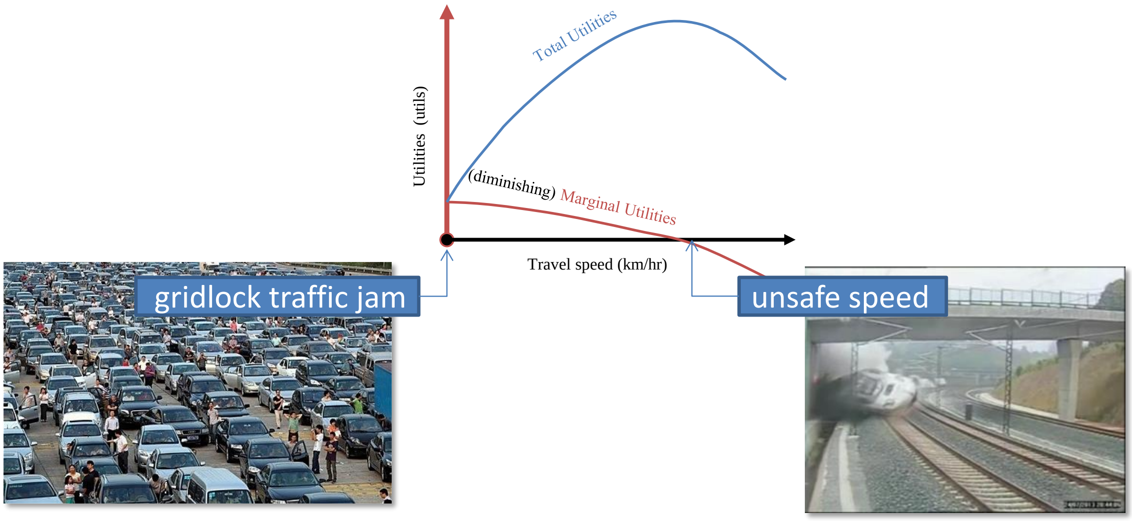
The approach used in the analysis is the Utilitarian Theory. Utility refers to usefulness, the ability of something to satisfy needs or wants. It represents satisfaction experienced by a consumer of a commodity or a good. Utility rate can be measured through:

- Marginal utility – changes of satisfaction gained from an additional unit increase or loss from a decrease in the consumption of that good or service. Marginal utility will diminish at the higher existing level of service as illustrated in Figure 3-1.

- Total utility – the sum of all the marginal utilities of the individual units.

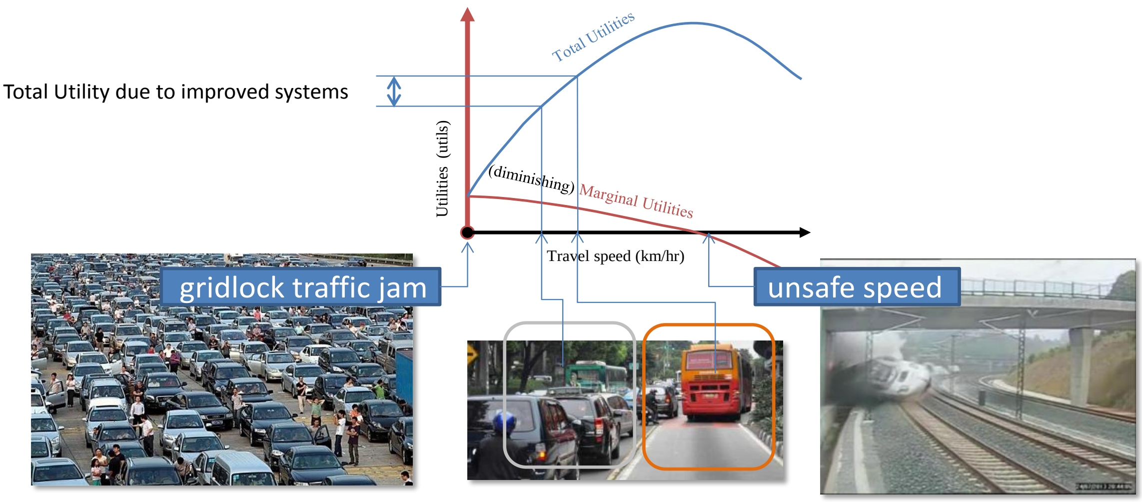
The utilitarian approach is highly relevant to the study. BRT improvement aims to increase the total utility of the commuters and, therefore, attract car users to use the BRT. This study will measure the preference to shift to the BRT due to the additional happiness (marginal utility) as the impact of increasing one unit of level of service (e.g., km/hr travel speed).

Figure 3-1: Marginal Utility Concept on BRT Service



Total utility (satisfaction) resulting in improved systems determines a preference to shift as shown in Figure 3-2:

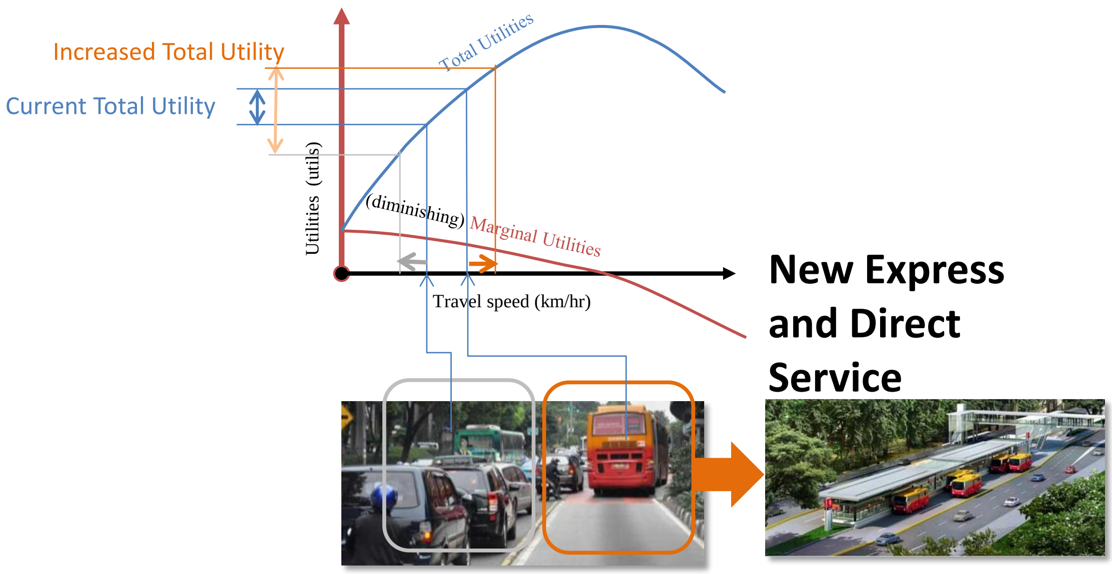
Figure 3-2: Total Utility and Preference to Shift



Increasing utility to promote modal shift can be carried out by increasing the speed of the new system and reducing the speed of private vehicles.

Modal shift from private cars to public transport is very urgent for reducing energy consumption in the transport sector especially in big cities such as the Jakarta metropolitan area. Those two options could be applied to encourage commuters to shift to BRT public transport. However, in this research, we only focus on increasing the speed of the new system by introducing express and direct service. This concept is shown in the Figure 3-3.

Figure 3-3: Increasing Utility to Promote Modal Shift



Research Design

Variables

The stated preference studies aimed to assess how respondents' choices vary in different hypothetical situations. Stated preference is a survey technique concerned with measuring and understanding the preferences underlying people's stated choices based on how they respond to the scenario. In the questionnaire, respondents were presented with choices of each scenario about what modal shift resulted from introducing express BRT at the current fare with some independent variables as follows:

1) reduced travel time,
2) minimize number of transfer, and
3) minimize transfer time.

Intervention to improve the service

To improve this hypothetical performance, a set of possible interventions for express service is proposed as follows:

1)direct route from origin to destination,
2)improved SOPs/information systems to reduce transfer time, and
3)improved infrastructure.

For each intervention, several scenarios are explained as below.

1) Direct route from origin to destination, options

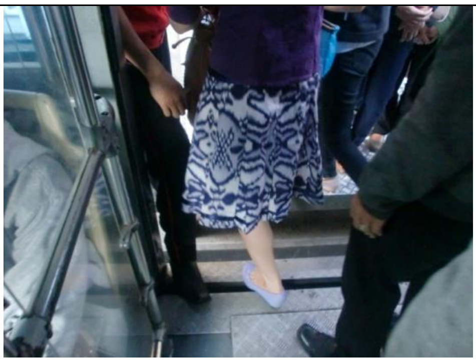
a) No transfer (transfer time = 0)

Figure 3-4: No Transfer Scenario

	This scenario describes a direct route from origin to destination (the bus stops only at the shelter of origin and last destination). It means the passengers will not have to transfer during their trip. As illustrated in the picture, the bus, which is full of passengers, does not stop at each shelter.

b) One transfer (with improved transfer time)

Figure 3-5: One Transfer Scenario (with improved transfer time)

	The passengers will transfer only once during their trip. They need to transfer at a shelter during their trip with improved transfer time.

2) Improved SOPs/information systems to reduce transfer time

a) Current procedure (15 minutes' transfer time)

Figure 3-6: 15 Minutes' Transfer Time

	Currently, passengers need 15 minutes to transfer at the shelter. As shown in Figure 3-6, there is a long queue at the shelter whilst passengers wait for the bus.

b) Minimum SOP improvement (10 minutes)

Figure 3-7: 10 Minutes' Transfer Time

	This is to improve the SOP at the shelter, such as decreasing headway of the bus. As the result, the queue is shorter whilst passengers await the bus.

c) Maximum SOP improvement (five minutes)

Figure 3-8: Five Minutes' Transfer Time

	This scenario depicts a reduced transfer time of five minutes. The procedure consists of a maximum SOP improvement, such as the very close bus headway. Through this design, the passenger queue will be shorter than before.

3) Improved infrastructure

a) Existing infrastructure (at current travel time)

Figure 3-9: Existing Infrastructure

	As shown in the figure, the TransJakarta bus is still obstructed by other vehicles that pass through the bus way. Therefore, maximum travel speed cannot be reached because of the traffic jam. This situation lessens the willingness of private car users to use the BRT since travel time is the same.

b) Improved infrastructure (reduced travel time)

The most important way to reduce travel time is by improving the infrastructure through the following:

- Sterile dedicated lane

Figure 3-10: Sterile Dedicated Lane

	Sterilisation of the bus way makes TransJakarta travel time faster than that of private vehicles. As shown on Figure 3-10, car users will greatly desire to move to the TransJakarta lane.

- Passing place

Figure 3-11: Passing Place

	This scenario needs wide spaces for implementation. This solution can enable the express bus to pass the regular bus so its travel time would be faster than that of the regular. Seizing the car user space can function as a ‘push factor’ to make people move to use TransJakarta.

- Bus priority signal

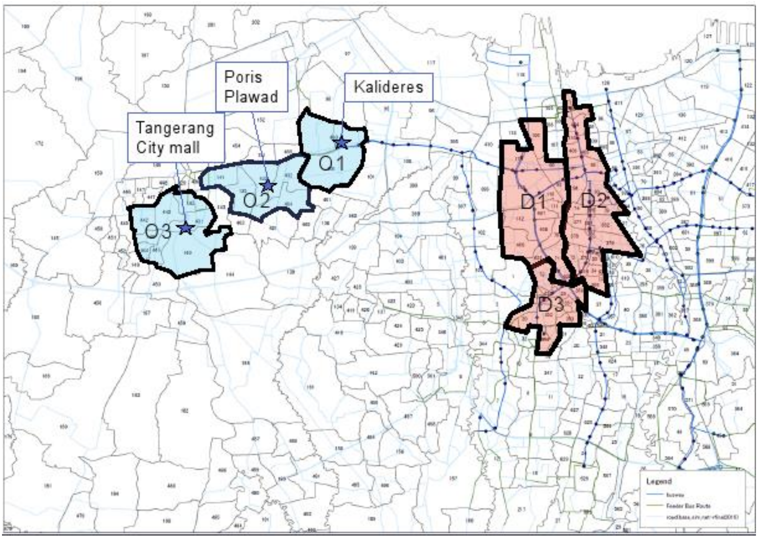
Figure 3-12: Bus Priority Signal

	Using intelligent transport systems can be a solution to improve the infrastructure. Based on the signal emitted by TransJakarta, the detector will automatically change the traffic light to green so that there are no stops for TransJakarta at intersections.

Corridor, Origin, and Destination

This survey was conducted at Corridor 3 as a sample for all corridors of TransJakarta. Therefore, targeted private car commuters for this survey were restricted based on the origin–destination so that it is possible to shift using BRT Corridor 3 as shown by Figure 3-13.

Figure 3-13: Origin–Destination Zone



The origin zone consists of three areas around Tangerang City Mall, Poris Plawad bus station, and Kalideres shelter. However, the destination zone consists of three zones around the city centre of Jakarta (D1, D2, and D3).

Method for data collection

To recognize the survey location, the respondent reaction, and to evaluate the survey method, a pilot survey was conducted three days before the final survey. It was conducted in one day by the surveyors to determine the best way to catch the respondents in each location. Moreover, a souvenir was given to attract respondents. The pilot survey revealed that the questionnaire design was capable of retrieving the required information on passenger willingness to shift from private cars to the BRT and obtain advice for the improvement of TransJakarta from its existing condition.

This survey targets two groups: BRT users who were expected to inform about improvement in services of TransJakarta at Corridor 3 and non-BRT users/private car commuters from Tangerang (the most possible shifting target to use Corridor 3) who were expected to reveal their willingness to shift to the BRT from eight choice sets of stated preference questionnaire.

The BRT user survey consisted of 50 (with 10 additional reserved) respondents who were found during morning rush hours (5:00–7:00 am) at

Kalideres shelter. It was conducted by four surveyors on February 25, 2014. On the other hand, the commuter survey consisted of 150 (with 30 additional reserved) respondents found at destination areas of commuters, such as office parking lots from mornings until afternoons and mall parking lots from afternoons to evenings. It was conducted by 10 surveyors on February 25–26, 2014. Commuter respondents were identified by their car IDs from the area of origin (Tangerang).

Valid answered forms should meet the validation criteria as follows:

1. Car ID – this is a MUST to be put on the form to screen the area of origin.
2. The number of forms reaches the target (50 for BRT users, 150 for commuters).
3. All the questions were answered completely

Structure of the questionnaire

The questionnaire consists of the respondent's profile, stated preference, and open questions.

1. Respondent's profile

To ensure that the survey was representative of the desired target audience, demographic and socioeconomic characteristics were collected from each respondent. Characteristics collected or respondent's profile included in the first part of the questionnaire consists of the following:

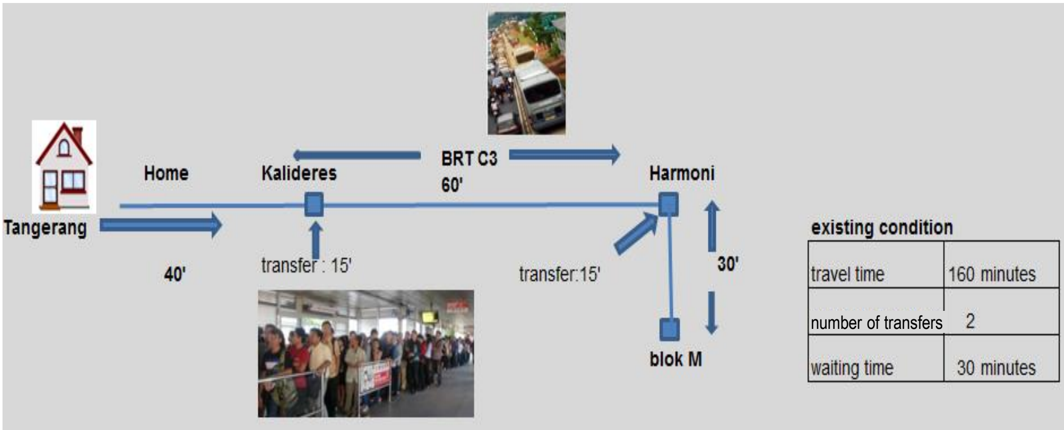
a) origin
b) destination
c) travel purpose
d) gender
e) age
f) job
g) education
h) the vehicle used for daily trips? Reason?
i) travel patterns in detail (each departure – time and location; each arrival – time and location, distance, mode, and transfer time)
j) income/month

k) household expenditure
l) transportation expenditure
m) When the respondent can use TransJakarta, what vehicle was needed before (i.e., to connect from origin to first shelter)?
n) When the respondent can use TransJakarta, what vehicle was needed after (i.e., to connect from shelter to last destination)?

2. Stated preference questions

The stated preference questionnaire is dedicated only for commuters or non-BRT users. Respondents were shown cards of various scenarios, then asked to decide whether they will shift to the BRT.
Before answering the stated preference questions, respondents were updated on the existing condition of TransJakarta (see Figure 3-14).

Figure 3-14: Existing Condition of TransJakarta Corridor 3



A detailed explanation of the existing condition of TransJakarata Corridor 3 is as follows:

a) The average travel time from home (at Tangerang) to the first shelter of TransJakarta (Kalideres) at Corridor 3 is 40 minutes

Figure 3-15: 15 Minutes' Transfer Time

At Kalideres shelter, 15 minutes is the maximum transfer time (for ticket queuing and waiting for the bus).

Figure 3-16: Existing Travel Time = 60 Minutes

Currently, the average travel time using TransJakarta from Kalideres shelter through Harmoni shelter is 60 minutes. A lot of private cars using the dedicated bus way prevent TransJakarta to run at maximum speed, hence, affecting travel time.

b) If the passenger needs to continue the trip through Blok M shelter, he or she has to transfer at Harmoni shelter and queue for 15 minutes for the ticket and the bus.

c) The average travel time using TransJakarta from Harmoni shelter to Blok M shelter is 30 minutes.

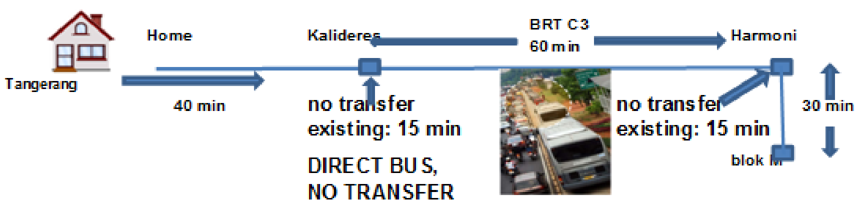
Figure 3-17 presents an example of stated preference choice for respondents. Full questionnaires are available in the appendixes.

Figure 3-17: Example of Stated Preference Questionnaire

18

Reduced travel time (minutes)	30
Number of Shelter transfers	0
Transfer time (minutes)	0
By services above, what will you do	………

☐ Certainly Ride ☐ Doubtful ☐ Certainly Not Ride
☐ Probably Ride ☐ Probably not ride



Open question

The last part of this questionnaire is on the existing condition of TransJakarta. The respondents were asked what services of TransJakarta should be improved and why.

Utility Function Formulation Method

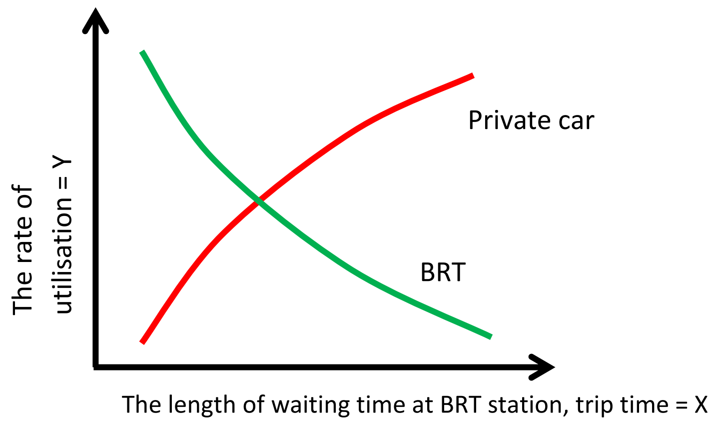
To explain the behaviour of respondents in choosing the transport mode, a statistical analysis with logit models was conducted. The model form is as follows:

$$\Pr[Y_j = 1 | X_{1j}, \ldots X_{k,j}] = \frac{1}{1 + \exp\left(-\beta_1^0 X_{1j} - \ldots - \beta_k^0 X_{kj}\right)} = \frac{1}{1 + \exp\left(-\sum_{i=1}^{k} \beta_i^0 X_{ij}\right)},$$

Where:
Pr = chance the respondent will shift
Y = respondent's answer, where 1 means certainly shifting, 0 means certainly not shifting
X = factor affected

Graphically, the model is presented in Figure 3-18.

Figure 3-18: Logit Model Illustration



Based on the model, one will know how private car users will respond to several variable sets, including a reduction in travel time, waiting time at the bus stop, and number of transfers.

Moreover, to confirm whether BRT service improvement could achieve the targeted modal share in the policy document, a comparison to government target share of urban public transport in the Greater Jakarta area, which is approximately 30 percent in 2015,[3] was performed. With current public transport share of 16.7 percent and cars 17.4 percent[4], the target of 30 percent share suggests 76 percent of car users shifting. The above utility function then is used to find the possible intervention to achieve the targeted modal share of public transport.

Result

Preference description

Priority for improvement

For each type of questionnaire, respondents were asked about the priority for TransJakarta improvement based on their desire. The following is the hierarchy of priorities—with number one as the highest—as requested by respondents: (1) improvements in bus facilities; (2) improvement of SOPs, schedule, and driver's ability; and (3) improvement of safety facilities. All these priority improvements could potentially attract people to use TransJakarta. Detailed results are illustrated in Figure 3-19.

[3] Rencana Induk Transportasi Perkotaan Jabodetabek (SITRAMP), 2003.
[4] JUTPI, 2010.

Figure 3-19: First Priority for Improvement

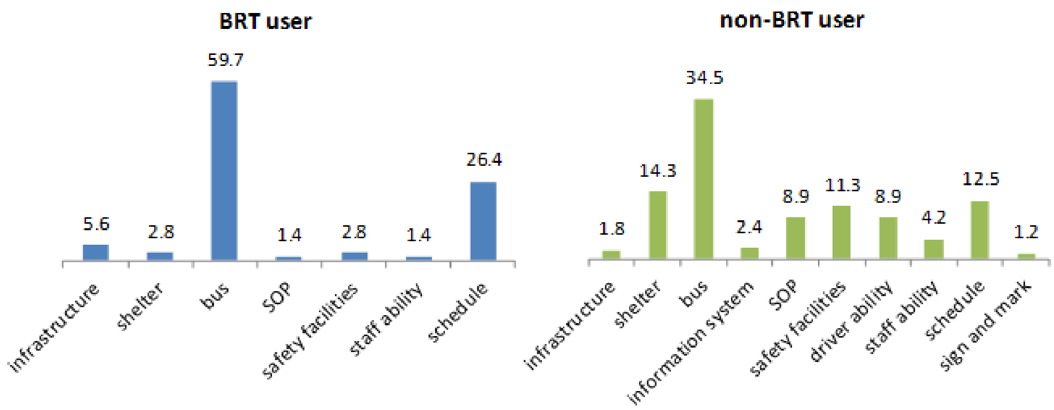
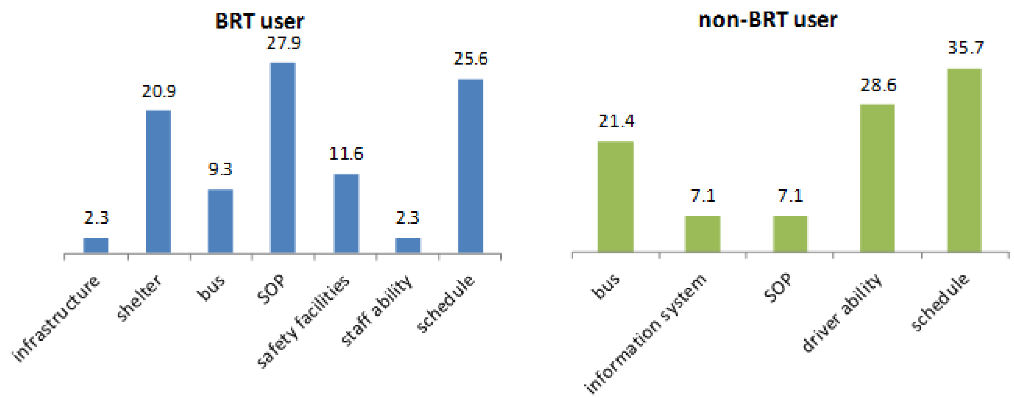
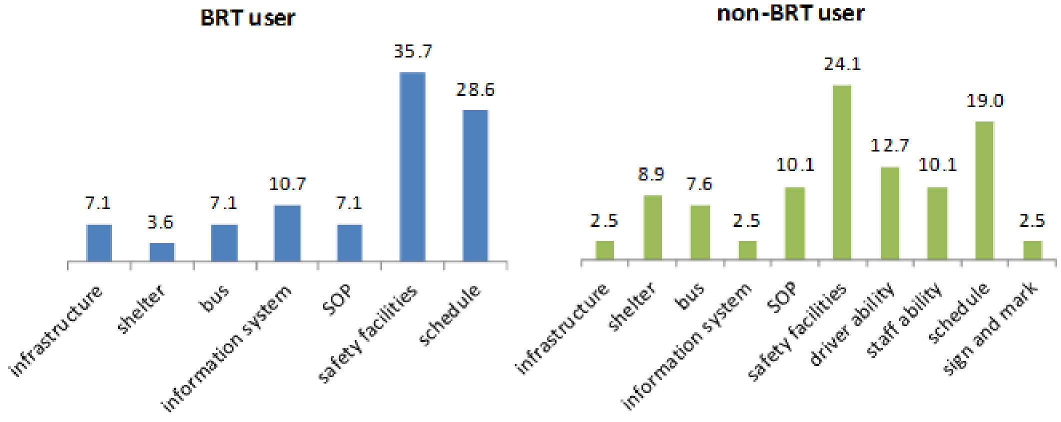


Figure 3-20: Second Priority for Improvement



Note :SOP = standard operating procedure.

Figure 3-21: Third Priority for Improvement

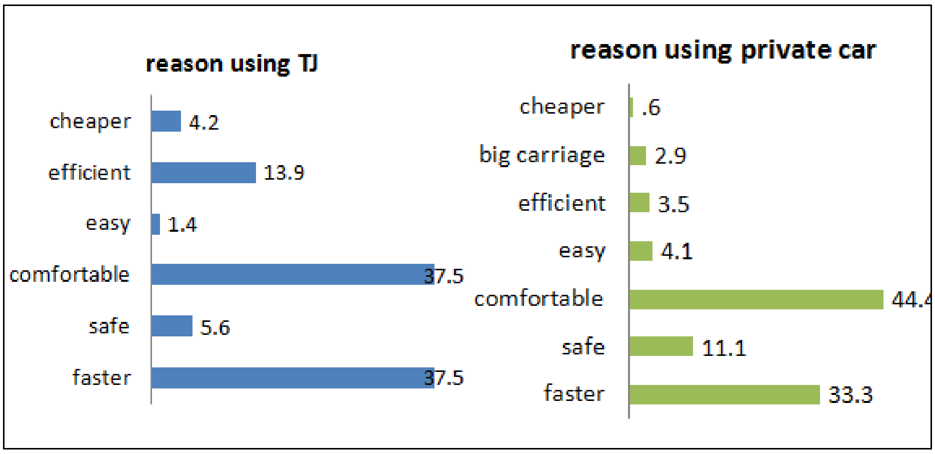


Note :SOP = standard operating procedure.

Reasons for using TransJakarta or private cars

The major reasons BRT users and private car users prefer their particular mode of transport are basically the same. As can be seen from Figure 3-22, BRT users said that they like to use TransJakarta since it is comfortable and can take them faster to their destination. Private car users said that their cars were more comfortable and faster to use than other modes.

Figure 3-22: Reasons for Using TransJakarta or Private Car

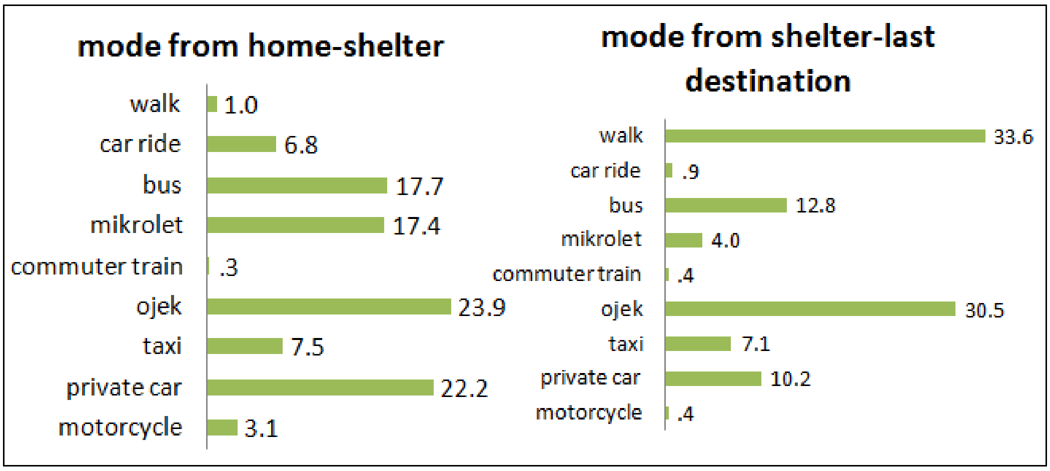


Note :TJ = TransJakarta.

Non-user: If I can use TransJakarta

Before starting the stated preference questions, private car users were asked what complementary transport mode they need if they can use TransJakarta as their daily transport. The top four choices were *ojek* (motorcycle taxi), private car, and bus or *mikrolet* (minibus); they said these can take them from home to the closest TransJakarta shelter. On the other end, they prefer to walk or use *ojek* to bring them from the shelter to the last destination.

Figure 3-23: Mode Needed from Home to Shelter and from Shelter to Last Destination



Other survey results on respondent characteristics are found in the appendix.

Utility function

The model was formulated for three scenarios—namely, the pessimistic scenario, the moderate, and the optimistic. Each scenario has the following assumptions:

- Pessimistic scenario – respondents who answered 'doubtful' would not switch to the BRT
- Moderate scenario – respondents who answered 'doubtful' were omitted in the calculation
- Optimistic scenario – respondents who answered 'doubtful' would switch to the BRT

Calculations were performed using the SPSS software, with the results of calculations for each scenario presented as follows:
Pessimistic scenario: doubtful~not shifting

Logit model calculation for the pessimistic scenario shows the following results:

Table 3-1: Logit Model Result – Pessimistic Scenario

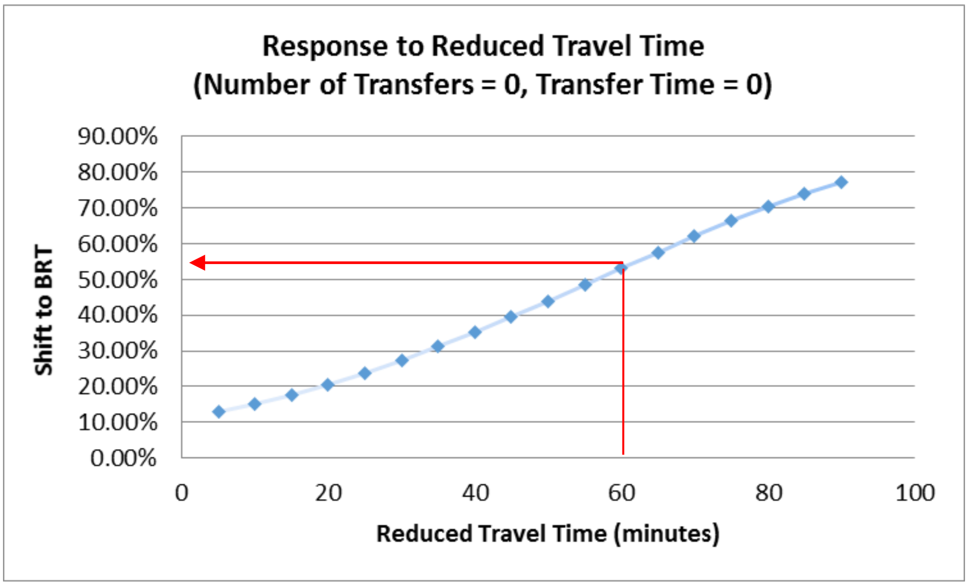
Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	RTT	.037	.004	90.253	1	.000	1.037
	NoT	-1.087	.257	17.834	1	.000	.337
	TT	-.052	.026	4.119	1	.042	.949
	Constant	-2.083	.227	84.468	1	.000	.125

Note :RTT = reduced travel time, NoT = number of transfers, TT = transfer time.

The result shows all the variables with a significance level of below one percent (variables NoT and RTT), and below five percent (variable TT).

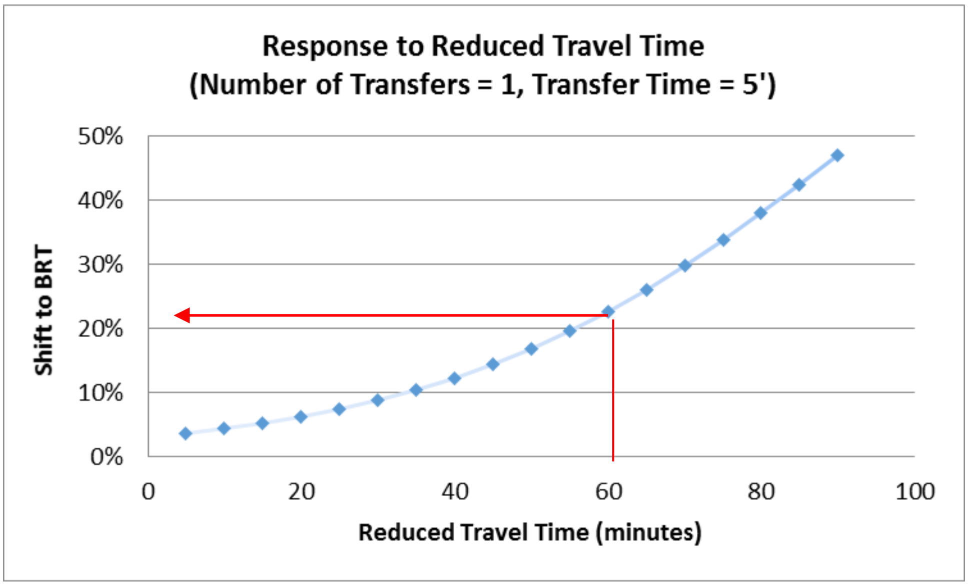
Graphically, the modelling results for variations of a reduction in travel time are presented in Figure 3-24.

Figure 3-24: Response to Reduced Travel Time – Pessimistic Scenario



To see the impact of other variables, such as the number of transfers and the transfer time, the level of response to reduction in travel time can be calculated with a variation of different values on the two variables (see Figure 3-25).

Figure 3-25: Response to Reduced Travel Time – Pessimistic Scenario (Sensitivity Analysis)



The figure shows the respondents' sensitivity to changes in the number of transfers and transfer time. The changes led to a decrease in the willingness to shift from about 50 percent to about 20 percent in decreased travel time by one hour.

Moderate: doubtful~omitted

Calculation results of the logit model for moderate scenario are shown in Table 3-2.

Table 3-2: Logit Model Result – Moderate Scenario

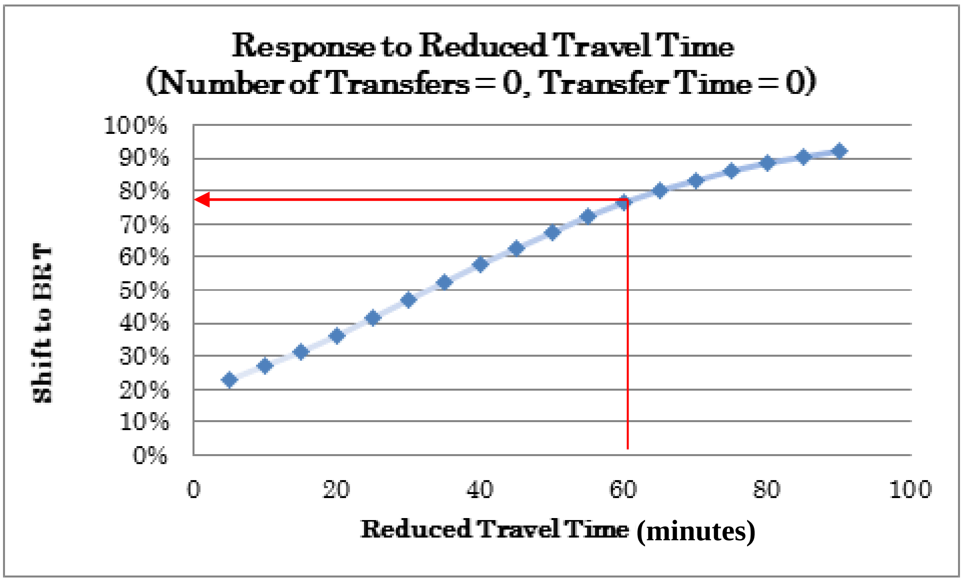
Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	RTT	.043	.005	91.799	1	.000	1.044
	NoT	-1.642	.278	34.868	1	.000	.194
	TT	-.036	.027	1.817	1	.178	.964
	Constant	-1.427	.257	30.699	1	.000	.240

Note :RTT = reduced travel time, NoT = number of transfers, TT = transfer time.

The results show that the variables RTT and NoT are significant, with a value of below one percent. Whilst the TT variable is not significant at the five percent level, it was still used in the model because of its influence to meet the assumption of theory (additions of TT will reduce the willingness to shift).

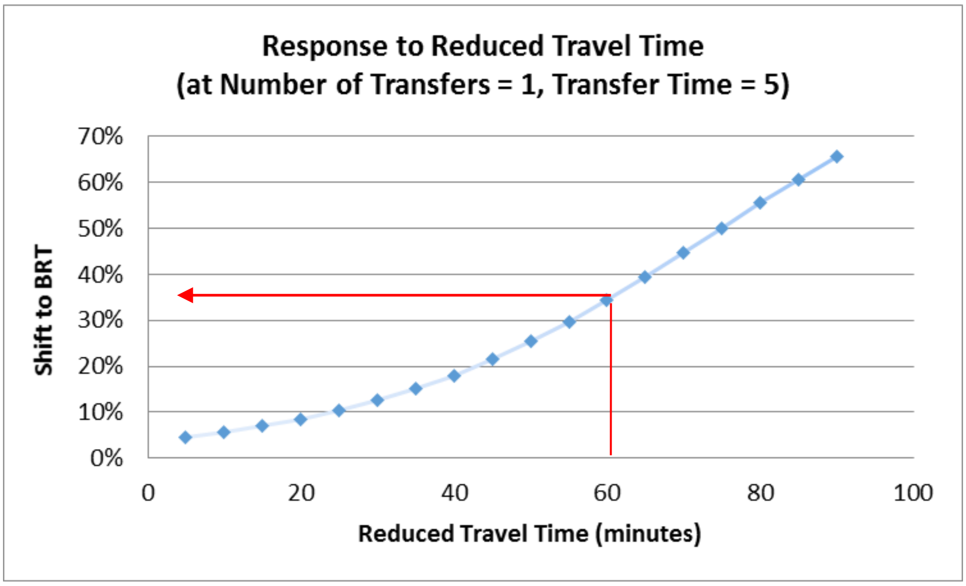
Graphically, with variations in reduced travel time, various scenarios of time travel and other variables assumed to be zero, the result is as follows:

Figure 3-26: Response to Reduced Travel Time – Moderate Scenario



When the number of transfers is one and transfer time is five minutes, the results are illustrated as follows:

Figure 3-27: Response to Reduced Travel Time – Moderate Scenario (Sensitivity Analysis)



These results indicate a decrease of willingness to shifting from about 75 percent to about 30 percent.

Optimistic: doubtful~shifting

The calculation results of the logit model for the optimistic scenario are shown in Table 3-3.

Table 3-3: Logit Model Result – Optimistic Scenario

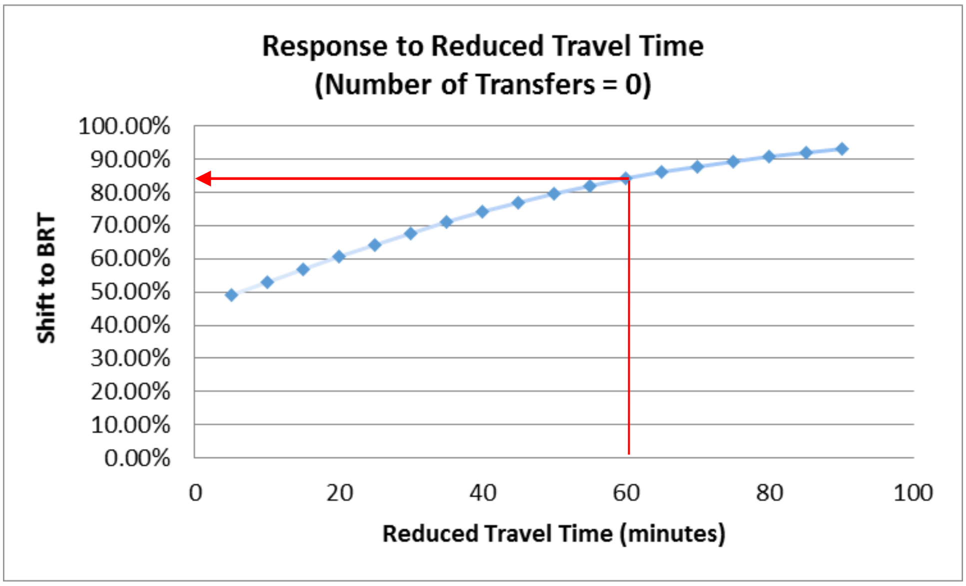
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 2[b]	RTT	,031	,003	102,952	1	,000	1,031
	NoT	-1,273	,114	123,976	1	,000	,280
	Constant	-,187	,177	1,108	1	,292	,830

Note : RTT = reduced travel time, NoT = number of transfers, TT = transfer time.

The results show variables RTT and NoT are significant to use in the model, with a level of below one percent, while the variable TT is not significant and the effect is contrary to the assumption of the theory, hence, it is removed from the model.

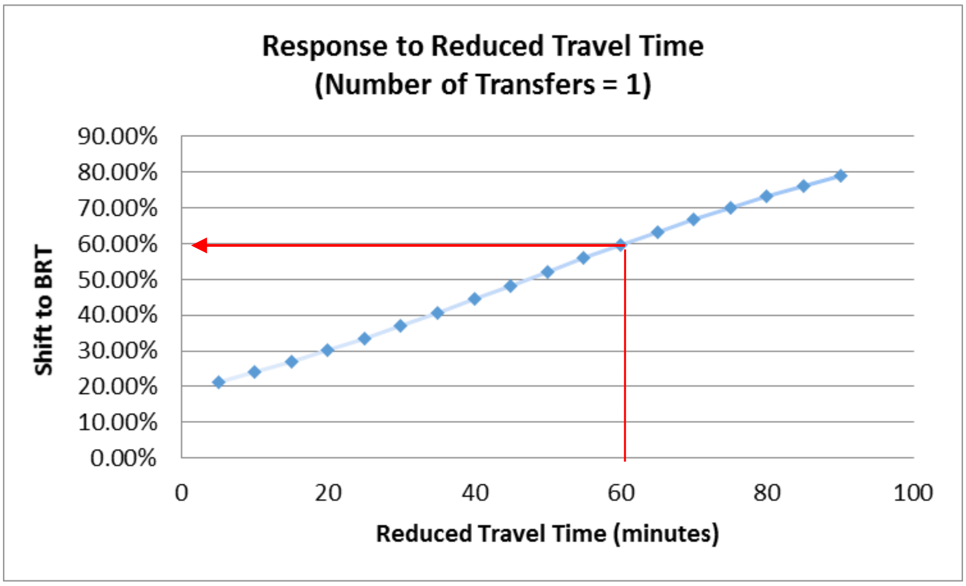
Graphically, with various scenarios of time travel and other variables zero, the result is as follows:

Figure 3-28: Response to Reduced Travel Time – Optimistic Scenario



If the number of transfers = 1, the result is shown on Figure 3-29.

Figure 3-29: Response to Reduced Travel Time – Optimistic Scenario (Sensitivity Analysis)

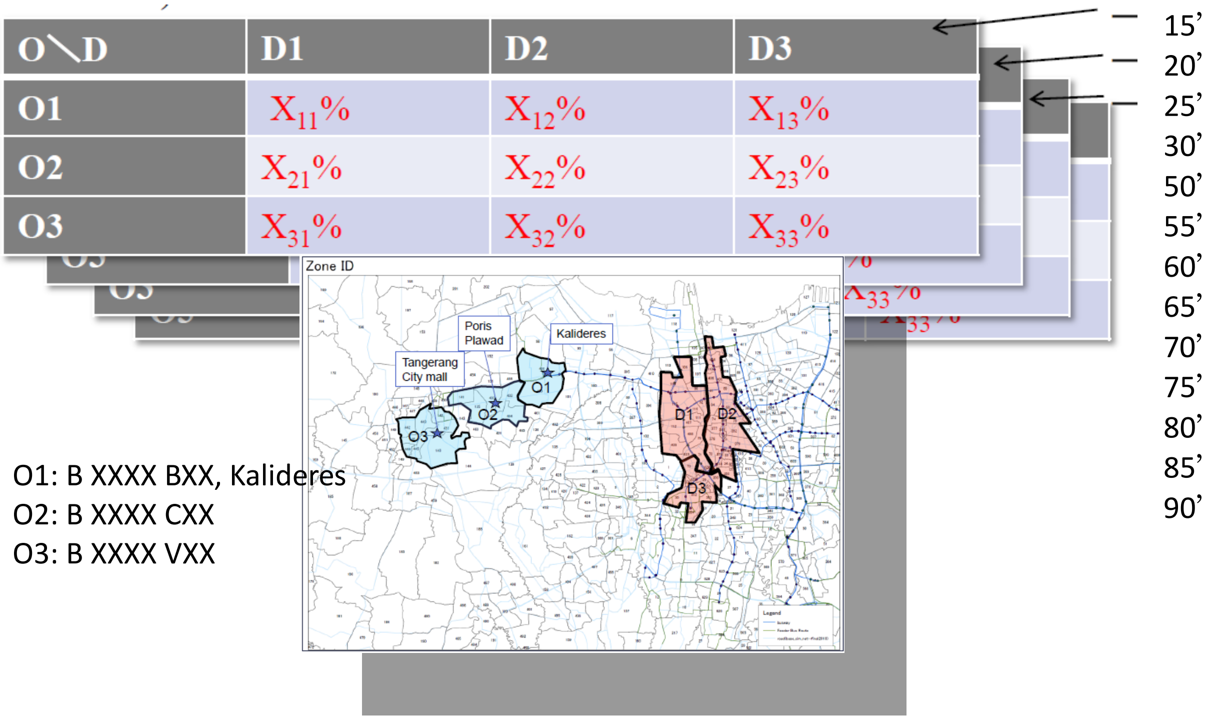


These results indicate a decrease of willingness to shift from about 80 percent to about 60 percent.

Ratio of car users shifting to BRT

The model presented earlier is a general model applicable to all conditions. In fact, there are different characteristics in different origin destinations due to the different routes, important variables, and different treatment needs (see Figure 3-30). These different characteristics are calculated as weight in general formula, so each origin destination will have a different amount of shifting with general condition.

Figure 3-30: Logit Model Result Summary Illustration



The results of shifting calculation for different characteristics on several scenarios are presented in Tables 3-5 to 3-7. The cells in green indicate the achieved policy target of 76 percent public transport shifting.

Table 3-4: Logit Model Result Sheet – Pessimistic Scenario

1	SYSTEMS TIME REDUCTION:	15		NoT:	1	TT:	15		
	OD Time Reduction	D1	D2	D3		Car to BRT Shift	D1	D2	D3
	O1	0.0	15.0	15.0		O1	1.89%	3.24%	3.24%
	O2	0.0	15.0	15.0		O2	1.89%	3.24%	3.24%
	O3	0.0	15.0	15.0		O3	1.89%	3.24%	3.24%
2	SYSTEMS TIME REDUCTION:	20		NoT	1	TT:	10		
	OD Time Reduction	D1	D2	D3		Car to BRT Shift	D1	D2	D3
	O1	5.0	20.0	20.0		O1	2.92%	4.96%	4.96%
	O2	5.0	20.0	20.0		O2	2.92%	4.96%	4.96%
	O3	5.0	20.0	20.0		O3	2.92%	4.96%	4.96%
3	SYSTEMS TIME REDUCTION:	25		NoT:	1	TT:	5		
	OD Time Reduction	D1	D2	D3		Car to BRT Shift	D1	D2	D3
	O1	10.0	25.0	25.0		O1	4.48%	7.52%	7.52%
	O2	10.0	25.0	25.0		O2	4.48%	7.52%	7.52%
	O3	10.0	25.0	25.0		O3	4.48%	7.52%	7.52%
4	SYSTEMS TIME REDUCTION:	30		NoT:	0	TT:	0		
	OD Time Reduction	D1	D2	D3		Car to BRT Shift	D1	D2	D3
	O1	0.0	30.0	30.0		O1	11.08%	27.31%	27.31%
	O2	0.0	30.0	30.0		O2	11.08%	27.31%	27.31%
	O3	0.0	30.0	30.0		O3	11.08%	27.31%	27.31%
5	SYSTEMS TIME REDUCTION:	50		NoT:	1	TT:	15		
	OD Time Reduction	D1	D2	D3		Car to BRT Shift	D1	D2	D3
	O1	33.6	76.3	40.1		O1	6.23%	24.22%	7.78%
	O2	75.5	79.3	50.6		O2	23.68%	26.34%	11.05%
	O3	80.7	77.9	50.0		O3	27.36%	25.36%	10.84%
6	SYSTEMS TIME REDUCTION:	55		NoT:	1	TT:	10		
	OD Time Reduction	D1	D2	D3		Car to BRT Shift	D1	D2	D3
	O1	38.6	81.3	45.1		O1	9.38%	33.23%	11.62%
	O2	80.5	84.3	55.6		O2	32.58%	35.77%	16.21%
	O3	85.7	82.9	55.0		O3	36.98%	34.60%	15.92%
7	SYSTEMS TIME REDUCTION:	60		NoT:	1	TT:	5		
	Real	D1	D2	D3		Car to BRT Shift	D1	D2	D3
	O1	43.6	86.3	50.1		O1	13.89%	43.67%	17.00%
	O2	85.5	89.3	60.6		O2	42.95%	46.45%	23.16%
	O3	90.7	87.9	60.0		O3	47.75%	45.18%	22.78%
8	SYSTEMS TIME REDUCTION:	65		NoT:	0	TT:	0		
	Real	D1	D2	D3		Car to BRT Shift	D1	D2	D3
	O1	33.6	91.3	55.1		O1	30.02%	78.17%	48.60%
	O2	75.5	94.3	65.6		O2	66.68%	80.02%	58.18%
	O3	80.7	92.9	65.0		O3	70.85%	79.19%	57.66%

Table 3-5: Logit Model Result Sheet – Moderate Scenario

1	SYSTEMS TIME REDUCTION:	15		NoT:	1	TT:	15			
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3	
	O1	0.0	15.0	15.0		O1	2.63%	4.92%	4.92%	
	O2	0.0	15.0	15.0		O2	2.63%	4.92%	4.92%	
	O3	0.0	15.0	15.0		O3	2.63%	4.92%	4.92%	
2	SYSTEMS TIME REDUCTION:	20		NoT	1	TT:	10			
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3	
	O1	5.0	20.0	20.0		O1	3.86%	7.15%	7.15%	
	O2	5.0	20.0	20.0		O2	3.86%	7.15%	7.15%	
	O3	5.0	20.0	20.0		O3	3.86%	7.15%	7.15%	
3	SYSTEMS TIME REDUCTION:	25		NoT:	1	TT:	5			
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3	
	O1	10.0	25.0	25.0		O1	5.65%	10.29%	10.29%	
	O2	10.0	25.0	25.0		O2	5.65%	10.29%	10.29%	
	O3	10.0	25.0	25.0		O3	5.65%	10.29%	10.29%	
4	SYSTEMS TIME REDUCTION:	30		NoT:	0	TT:	0			
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3	
	O1	0.0	30.0	30.0		O1	19.36%	46.86%	46.86%	
	O2	0.0	30.0	30.0		O2	19.36%	46.86%	46.86%	
	O3	0.0	30.0	30.0		O3	19.36%	46.86%	46.86%	
5	SYSTEMS TIME REDUCTION:	50		NoT:	1	TT:	15			
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3	
	O1	33.6	76.3	40.1		O1	10.39%	42.45%	13.31%	
	O2	75.5	79.3	50.6		O2	41.60%	45.71%	19.50%	
	O3	80.7	77.9	50.0		O3	47.24%	44.22%	19.10%	
6	SYSTEMS TIME REDUCTION:	55		NoT:	1	TT:	10			
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3	
	O1	38.6	81.3	45.1		O1	14.72%	52.34%	18.61%	
	O2	80.5	84.3	55.6		O2	51.47%	55.63%	26.50%	
	O3	85.7	82.9	55.0		O3	57.14%	54.13%	26.01%	
7	SYSTEMS TIME REDUCTION:	60		NoT:	1	TT:	5			
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3	
	O1	43.6	86.3	50.1		O1	20.44%	62.04%	25.39%	
	O2	85.5	89.3	60.6		O2	61.22%	65.11%	34.92%	
	O3	90.7	87.9	60.0		O3	66.49%	63.73%	34.35%	
8	SYSTEMS TIME REDUCTION:	65		NoT:	0	TT:	0			
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3	
	O1	33.6	91.3	55.1		O1	50.76%	92.63%	72.35%	
	O2	75.5	94.3	65.6		O2	86.36%	93.48%	80.49%	
	O3	80.7	92.9	65.0		O3	88.84%	93.11%	80.09%	

Table 3-6: Logit Model Result Sheet – Optimistic Scenario

1	SYSTEMS TIME REDUCTION:	15		NoT:	1	TT:	15		
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3
	O1	0.0	15.0	15.0		O1	18.85%	26.96%	26.96%
	O2	0.0	15.0	15.0		O2	18.85%	26.96%	26.96%
	O3	0.0	15.0	15.0		O3	18.85%	26.96%	26.96%
2	SYSTEMS TIME REDUCTION:	20		NoT	1	TT:	10		
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3
	O1	5.0	20.0	20.0		O1	21.32%	30.10%	30.10%
	O2	5.0	20.0	20.0		O2	21.32%	30.10%	30.10%
	O3	5.0	20.0	20.0		O3	21.32%	30.10%	30.10%
3	SYSTEMS TIME REDUCTION:	25		NoT:	1	TT:	5		
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3
	O1	10.0	25.0	25.0		O1	24.03%	33.44%	33.44%
	O2	10.0	25.0	25.0		O2	24.03%	33.44%	33.44%
	O3	10.0	25.0	25.0		O3	24.03%	33.44%	33.44%
4	SYSTEMS TIME REDUCTION:	30		NoT:	0	TT:	0		
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3
	O1	0.0	30.0	30.0		O1	45.34%	67.68%	67.68%
	O2	0.0	30.0	30.0		O2	45.34%	67.68%	67.68%
	O3	0.0	30.0	30.0		O3	45.34%	67.68%	67.68%
5	SYSTEMS TIME REDUCTION:	50		NoT:	1	TT:	15		
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3
	O1	33.6	76.3	40.1		O1	39.59%	70.98%	44.45%
	O2	75.5	79.3	50.6		O2	70.46%	72.88%	52.53%
	O3	80.7	77.9	50.0		O3	73.73%	72.02%	52.08%
6	SYSTEMS TIME REDUCTION:	55		NoT:	1	TT:	10		
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3
	O1	38.6	81.3	45.1		O1	43.33%	74.05%	48.29%
	O2	80.5	84.3	55.6		O2	73.57%	75.82%	56.36%
	O3	85.7	82.9	55.0		O3	76.61%	75.02%	55.92%
7	SYSTEMS TIME REDUCTION:	60		NoT:	1	TT:	5		
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3
	O1	43.6	86.3	50.1		O1	47.15%	76.90%	52.15%
	O2	85.5	89.3	60.6		O2	76.46%	78.53%	60.11%
	O3	90.7	87.9	60.0		O3	79.26%	77.80%	59.68%
8	SYSTEMS TIME REDUCTION:	65		NoT:	0	TT:	0		
	OD Time Reduction	D1	D2	D3		Car to BRT	D1	D2	D3
	O1	33.6	91.3	55.1		O1	70.06%	93.28%	81.95%
	O2	75.5	94.3	65.6		O2	89.49%	93.84%	86.26%
	O3	80.7	92.9	65.0		O3	90.93%	93.59%	86.05%

Discussion

The results confirm that improved BRT service could contribute to the achievement of target public transport modal share of 76 percent. Under the pessimistic scenario, this policy target is reached only at destination 2 (D-2), whilst at the optimistic scenario, all sets of origin and destination could reach above 76 percent of the policy target. In all the scenarios, major interventions are required especially to reduce travel time to 55–65 minutes. This could be done by combining all three infrastructure interventions—i.e., sterile dedicated lane, provision of passing places, and bus priority signal.

In addition, the result of modal shift to the BRT, which varies from 3 percent to 94 percent from the pessimistic to optimistic scenarios, is subject to further combined interventions. From the preference survey, some additional interventions might be required to attract more car users and, therefore, turn the pessimistic and moderate into more optimistic results, with the following priority improvements on (1) the quality of the bus and reliablity of the schedule; (2) the standard operating procedure and, therefore, the overall service; and (3) safety.

Our findings in general are in line with previous research on BRT modal shift preference. Khan, *et al.* (2007) also disclosed that the vehicle travel time is the most influencing factor for car users to shift in the Brisbane CBD corridor. Moreover, Nkurunziza, *et al.* (2012) stated that in a developing country (study case: Dar es Salam, Tanzania), comfort is the most valued attribute on how commuters perceive and value the proposed BRT service quality compared to travel time and travel fare. Our survey, which also outlines the priority factors, supports those suggestions to combining all critical success factors for shifing. Moreover, demand for express and direct bus service based on origin–destination of passengers was also demanded by existing BRT users in other corridors (Romadhona and Triyana, 2010).

In sum, the demand for such services has some policy implications and several preconditions. First, excellent infrastructure is the prerequisite to facilitate minimum travel time. Second, as infrastructure is the main success factor, the policy measure is beyond TransJakarta Authority. Therefore, cooperation among cities, districts and provinces, and sectors is critical. Since mobility of passengers in Greater Jakarta is also across provincial boundaries, a higher level of authority (national/subnational) is also required for the success of public transport revitalization.

Conclusion

The results confirmed that BRT service improvement could contribute to the achievement of the target modal share of 76 percent. This could be done by combining all three infrastructure interventions, i.e., sterile dedicated lane, provision of passing places, and bus priority signal.

Using the utility function provided, further reseach should be done to understand the extent of available infrastructure to support the BRT at the level of preferred service by potential users.

The demand for such improved services has some policy implications and several preconditions which involve provision of excellent infrastructure and a requirement for collaboration among cities, districts and provinces, and sectors as well as a higher level of authority (national/subnational).

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CHAPTER 4
Case Study: Simulation Analysis in Jakarta

Introduction

In this chapter, we will examine specific measures for promoting a modal shift from private to public transport in Jakarta. Methods of promoting a modal shift are diverse—ranging from 'soft' to 'hard'—and appear to vary in terms of benefits and costs. As such, we will apply simulation analysis to quantitatively assess the effect in reducing fuel consumption and its costs when each measure is implemented, and ultimately consider the effectiveness of each.

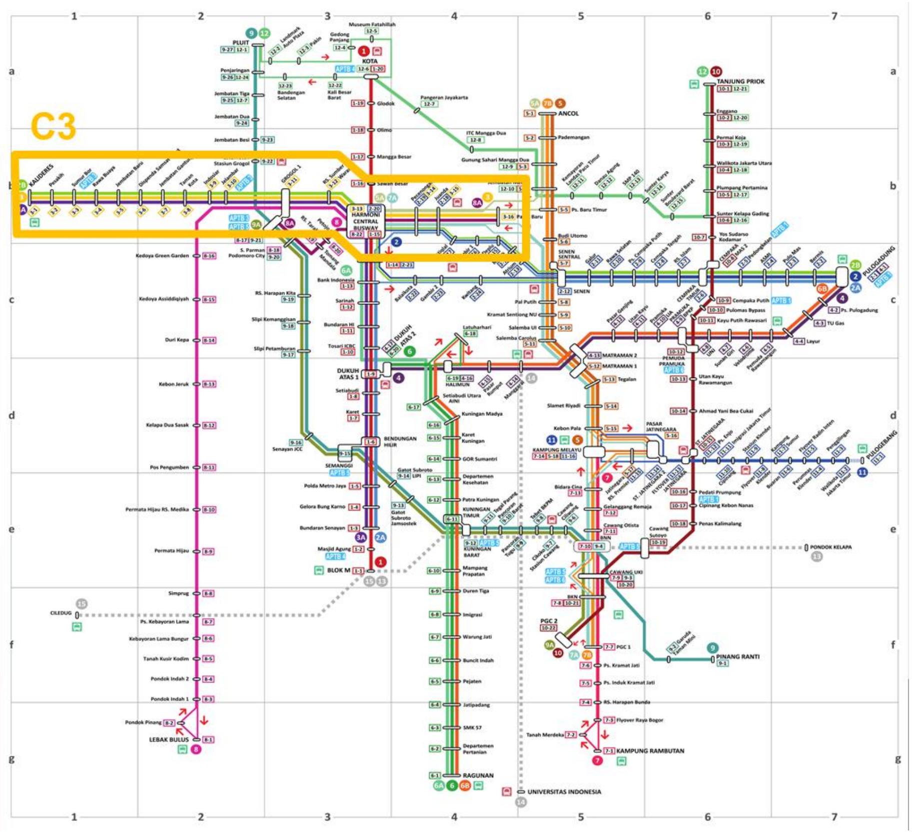
Our subject city is Jakarta, where the BRT system plays a key role in public transport. Consequently, it is necessary to improve the comparative attractiveness of the BRT and encourage its use to promote modal shift in the city. Hence, in this chapter, we will examine several methods for improving the attractiveness of the BRT and evaluate the degree to which each method encourages modal shift and the degree to which it results in reduced fuel consumption.

We will first analyze GPS (global positioning system) tracking data for Corridor 3 provided by TransJakarta to ascertain the current situation of BRT operations. Based on the results of this analysis, we will identify the specific challenges faced in BRT operations and propose solutions that may result in better operations. Then, we will calculate the amount of modal shift when each method is implemented, as well as the amount of reduction in fuel consumption, to evaluate the solutions proposed. Finally, we will discuss the results obtained.

Subject for Simulation-based Analysis

The BRT system in Jakarta began operation in 2004 under the name TransJakarta. As of April 2014, 12 so-called corridors operate within the city (Figure 4-1). TransJakarta is responsible for traffic within Jakarta, and has the combined role of linking the cities around Jakarta (Bogor, Depok, Tangerang, and Bekasi) with the central area of the city. In the study, we have selected Corridor 3—which connects Tangerang city with central Jakarta—as the target of analysis.

Figure 4-1: TransJakarta Route Map



Source: TransJakarta website, http://www.transjakarta.co.id

An overview of Corridor 3 is shown in Figure 4-2. Corridor 3 is a 19-km-long route linking Kalideres Station, close to the border with Tangerang city, with Pasar Bar Station in central Jakarta. Between these two, at Grogol and Harmoni Stations, the route intersects with Corridors 9 and 1, respectively. If we look at the number of passengers from each station in 2009 (Figure 4-3), we see that the highest numbers are at each of the terminal stations and on Corridor 1. According to this, we may expect that in the case of Corridor 3, passengers heading toward central Jakarta from around Kalideres Station and Tangerang city during the morning peak tend to use Corridor 3, and that a large number are connecting to Corridors 1 and 9 to commute to work or school. In this chapter, we will target these passengers commuting to work to determine the potential for modal shift.

Figure 4-2: Overview of Corridor 3

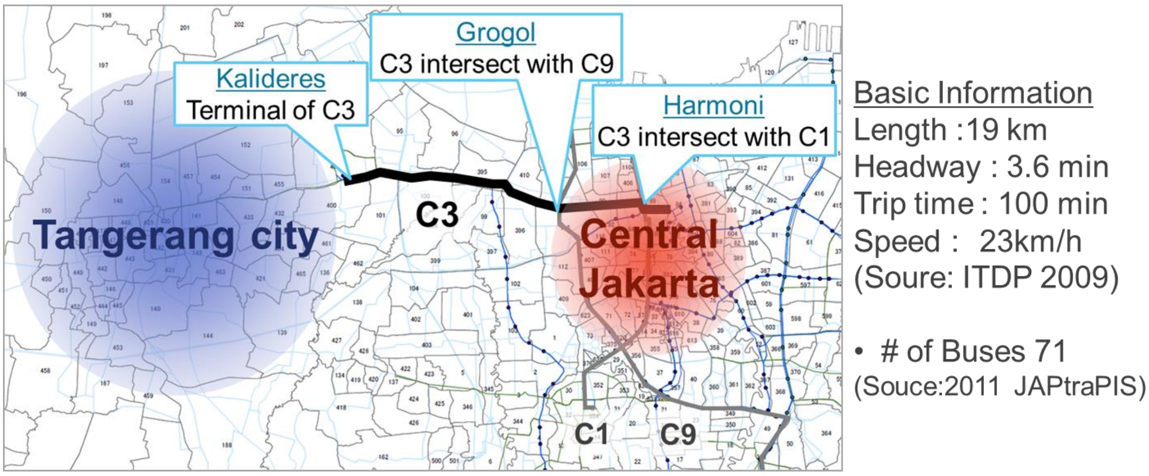
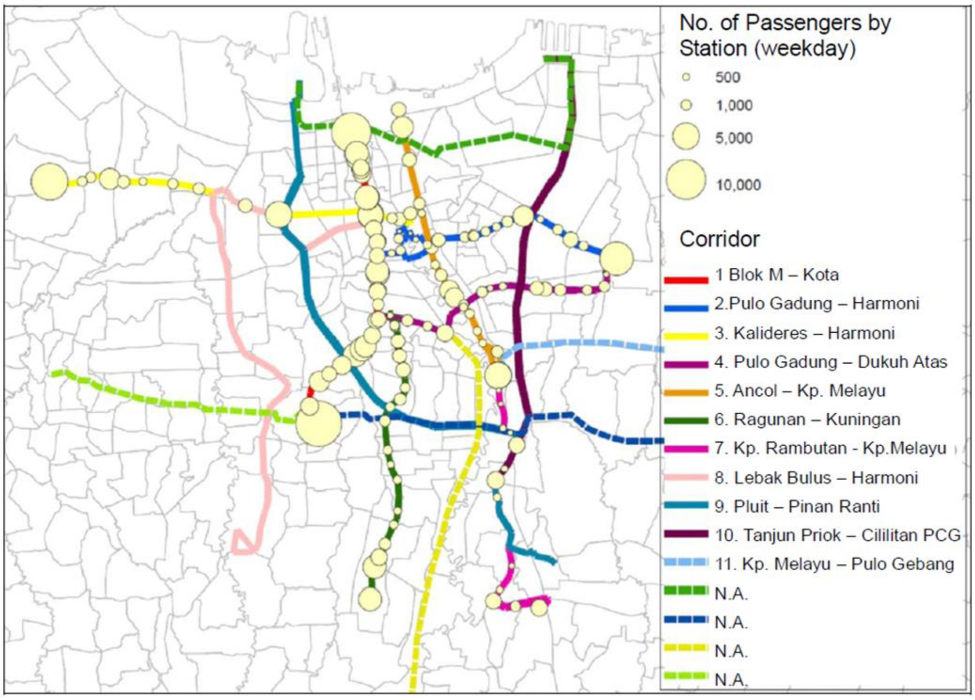


Figure 4-3: Number of Passengers/Day (weekdays) from Each Station, 2009



Source: JAPTraPIS.

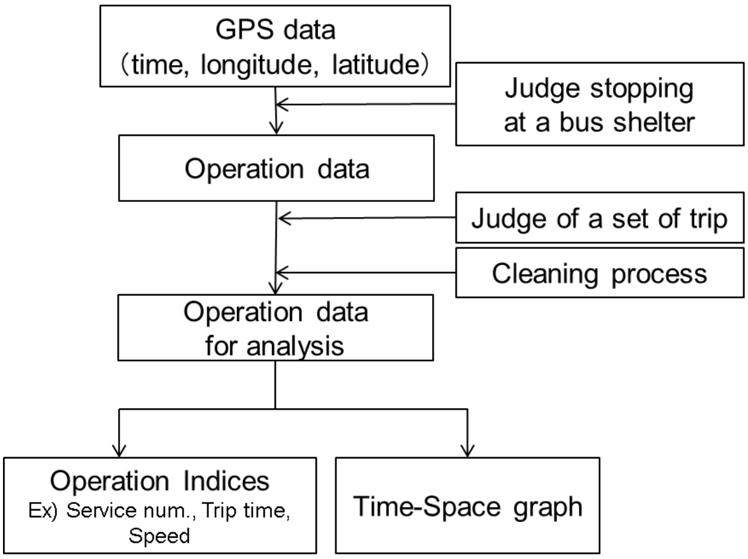
Analysis of Current BRT Operation

Method of analysis

To ascertain the current operations of Corridor 3 and deduce the challenges, we analyzed the bus GPS tracking data provided by TransJakarta. Data was compiled by measuring bus position information every 10 seconds, and so includes data on Corridor 3 operations, as well as on direct operations from Corridor 3 to Corridor 1 or Corridor 2. Data was collected for a one-month period in October 2013.

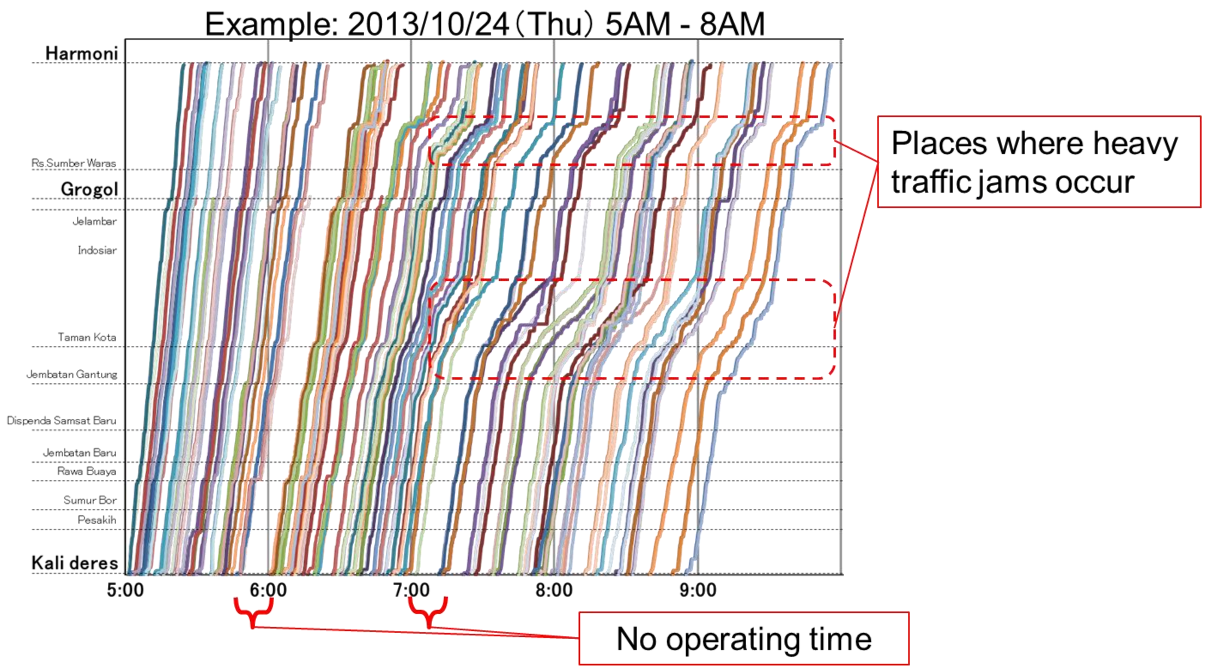
The data analysis process is shown in Figure 4-4. We produced operations data for analysis from the GPS data, and calculated time–space graphs and indices related to the operation situation (service numbers, trip times, speed, etc.).

Figure 4-4: Process of GPS Data Compilation



An example of a time–space graph we produced is shown in Figure 4-5. This uses lines to show the movement of each bus that departed from Kalideres Station between 5 am and 9 am on October 24, 2013 (Thursday). The steeper the gradient of the line, the faster the speed of the bus. Based on this time–space graph, we can see at a glance that there are sections where the operating speed drastically decreases from 7 am (morning rush hour), and that although the operating intervals are fairly spaced overall, there is a period of time before 6 am and another after 7 am when no buses operated. These are among the challenges faced in operations.

Figure 4-5: Example of Time–Space Graph



BRT operating situation

To ascertain the situation regarding BRT operations in the morning, we analyzed the time variation of the operation frequency (Figure 4-6). We can see that on weekdays, the operation frequency from 5 am to 6 am is stable, around 25 services per hour, which implies a high level of service. But during the morning peak period—6 am to 7 am and 7 am to 8 am—there is a very high degree of dispersion. For the operation frequency from 6 am to 7 am, on the day when the fewest services were running, there were 14; and on the day when most were running, there were 33, more than twice as many. Due to the relationship between service numbers and user waiting time at bus stops, we may assume that bus waiting times from day to day during the morning peak period largely vary. For service numbers on holidays, on the other hand, we see relatively smaller dispersions than those of weekdays. From the above, we may regard as a challenge the fact that the service numbers cannot be maintained as planned during the morning peak period on weekdays when there are the most users.

The variations of travel time from Kalideres to Harmoni are shown in Figure 4-7. On weekdays, the travel time in the hour from 5 am is short at around 30 minutes, and this varies very little. However, during the morning peak of 6 am to 7 am, the trip times become longer, and we see a very high degree of dispersion. The longest travel time over the period when the data was measured was 91.8 minutes, recorded on October 3 (Monday), which is extremely long. On the other hand, on holidays, the travel time stayed roughly the same as the hour from 5 am on weekdays. All these factors clearly reveal the necessity of improving the system to shorten travel times for the congested periods in the morning on weekdays, and thereby enable stable operation.

Figure 4-6: Histogram of the Operation Frequency on Weekdays (left) and on Holidays (right)

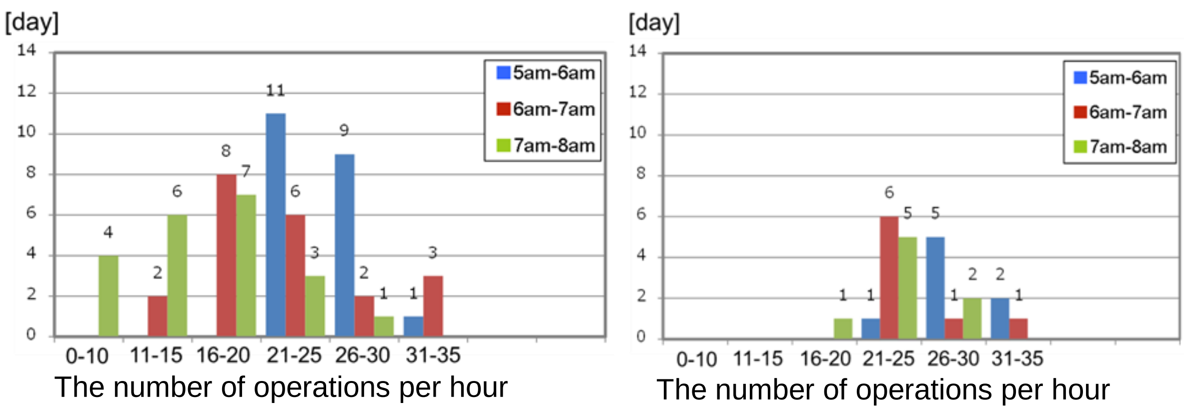
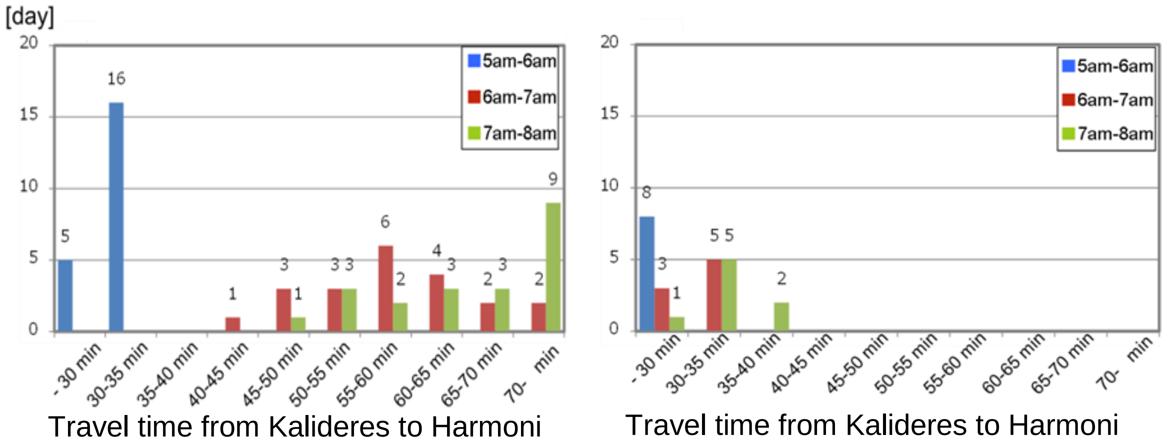


Figure 4-7: Histogram of Travel Time from Kalideres to Harmoni on Weekdays (left) and on Holidays (right)



As noted above, the operation of buses during the morning peak period is unstable. To determine the causes of this, we analyzed the average speeds and average trip times between each pair of stations (Figure 4-8). Looking first at the average speed on holidays, we find that four sections in particular have slower speeds than the others. Because these speeds are slow even on holidays when the amount of traffic is low, we can assume there is a problem in the road infrastructure. Among these four sections, the ones with the longest average travel times, and thus requiring particular improvements, are given below:

- Kalideres Station–Pesakih Station, (1) in Figure 4-8,
- Rs. Sumber Waras Station–Harmoni Station, (3) in Figure 4-8.

Looking next at the average speed on weekdays, we find that there is wide variation in travel speed depending on the time period for several sections. The speeds are reduced in the hours after 6 am and 7 am in particular; one reason could be the fact that during these hours in the morning, private transport interferes with BRT traffic (private traffic enters BRT-dedicated lanes). Of these, the sections requiring improvement that have a particularly wide variation in average travel speed are given below:

- Taman Kota Station–Indosiar Station, (2) in Figure 8;

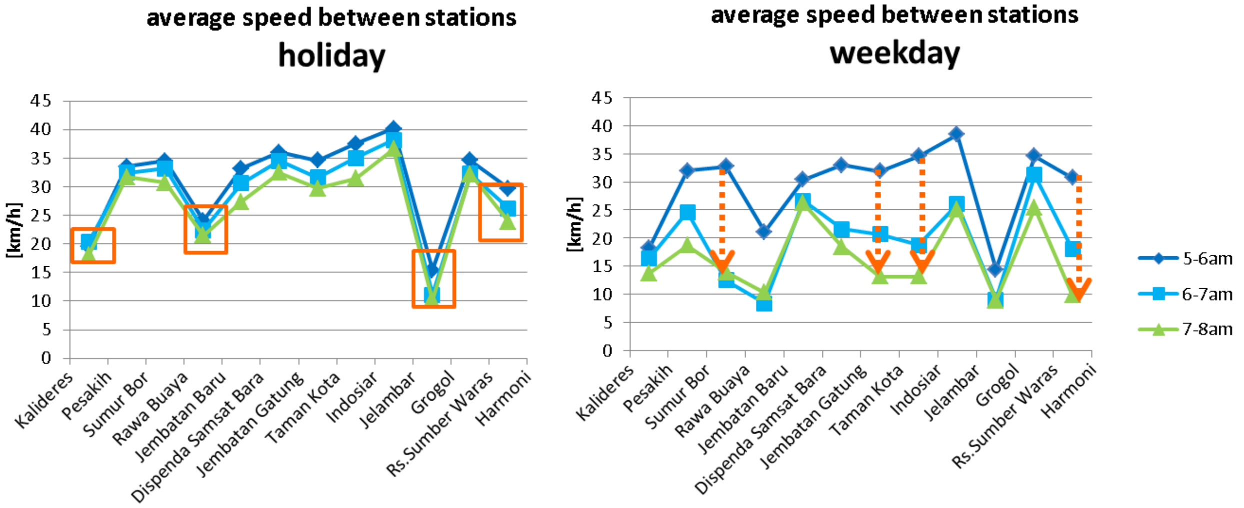
- Rs. Sumber Waras Station–Harmoni Station, (3) in Figure 8.

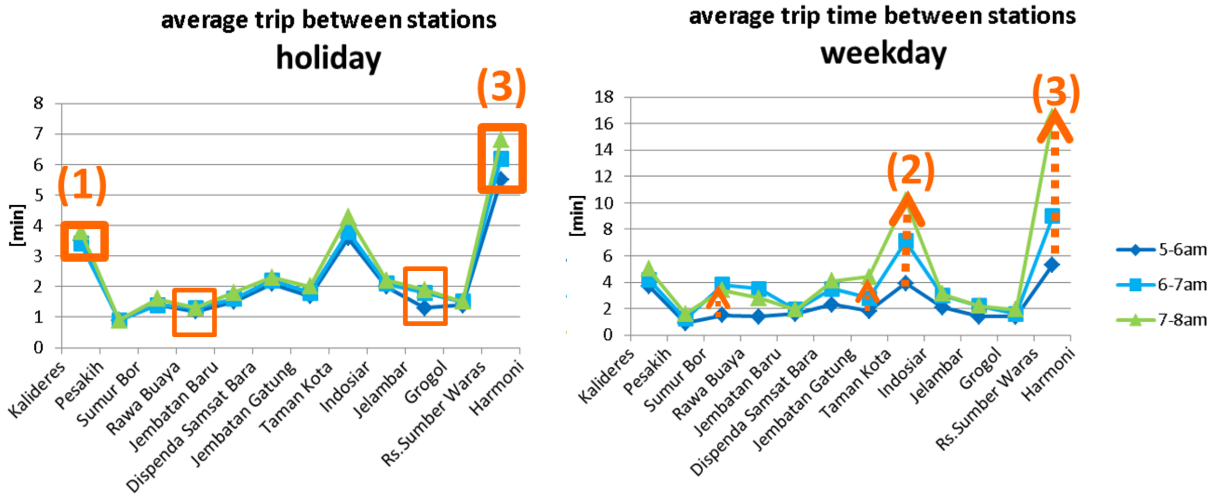
The causes of the decrease in speed on the sections mentioned above are as follows:

- the intersection infrastructure of the Kalideres Station exit and Daan Mogot road;
- interference with public transport on sections where there are no BRT-dedicated lanes and at their entrances/exits; and
- multiple intersection infrastructure, and interference with private transport on the bridge crossing Ciliwung River, and at its entrance/exit.

(A more detailed analysis of the average speeds between stations is given in Appendix A.)

Figure 4-8: Average Speed between Each Pair of Stations (upper) and Average Travel Time (lower) on Holidays (left) and on Weekdays (right)





Proposed Solutions

We considered solutions based on the above analysis. From the challenges deduced in section 3.2, the following improvement measures may be considered (left graph in Figure 4-9):

- construction of overpasses for sections (2) and (3) where intersection infrastructure are inadequate, and
- strengthening of the regulations for restricting inflow of private transport to BRT-dedicated lanes for sections (1) and (3) where there is a problem of interference with private transport.

Such regulations are in place even now, so priority in their implementation can be envisioned for the selected sections.

In this section, we assumed our target BRT users to be commuters travelling to work in central Jakarta from the vicinity of Tangerang city. The following methods for improvement may be considered from the perspective of improving convenience for these target users (right graph in Figure 4-9):

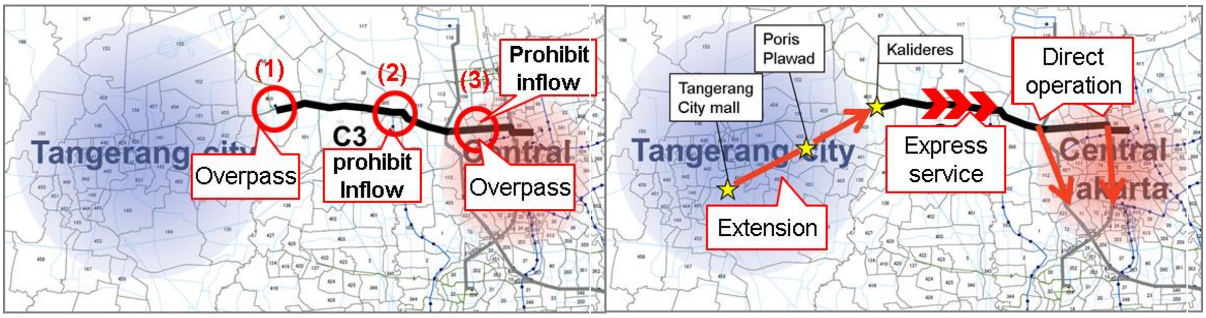
(1) Extending the route to improve access from Tangerang city. The bus stations for this extension to be applied can be envisioned as the locations proposed in JAPTraPis.[1]

[1] The Project for the Study on JABODETABK Public Transportation Policy Implementation Strategy in the Republic of Indonesia (JICA).

(2) Implementing direct operations to eliminate the loss of connection time. We will examine direct operations between the extended routes and Corridor 3, and between Corridor 3 and Corridor 1/Corridor 9.

(3) Implementing an express service on Corridor 3 to shorten trip times. Since express-service bus requires spaces for overtaking normal-service buses, overtaking spaces would be established in up to three places. As an overtaking lane at Dispenda Samsat Bara Station already exists, it would be possible to use this as well.

Figure 4-9: Locations for the Implementation of Improvement Measures



We have categorized the improvement measures listed above as either ‘soft’ methods, for which investment in road infrastructure is not required, and ‘hard’ methods, for which such investment is required. Solutions for cases A, B, C, and D in Table 4-1 are proposed. Each measure is explained as follows:

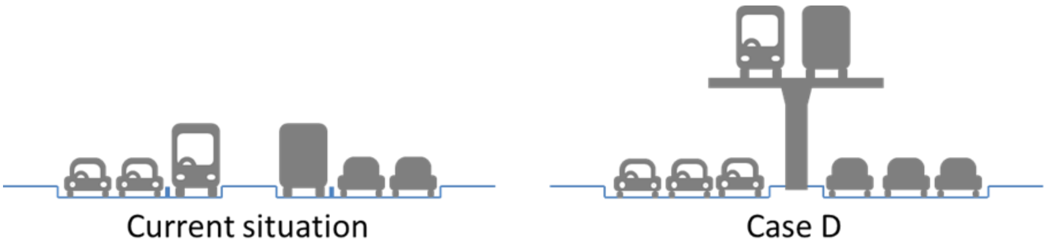
- Case A: strengthening of restrictions of private transport inflow
- Case B: implementation of all ‘soft’ methods
- Case C: implementation of partial improvement of infrastructure
- Case D: complete segregation of BRT and private transport, such as by elevating the entire BRT lane, and converting existing BRT-dedicated lanes into lanes for private transport (Figure 4-10).

A comparative assessment of these four measures is conducted in the next section. The basis for the cost estimates is described in Appendix B.

Table 4-1: Proposed Solutions

Measures		Case A	Case B	Case C	Case D
Soft	Strengthening restriction of inflow	✓	✓	✓	
	Express service		✓	✓	✓
	Extension + direct operation		✓	✓	✓
Hard	Overpass construction			✓	
	Total elevation				✓
Estimated Extra Cost (million USD) *Does not include land acquisition or operation costs		0	6	31	519

Figure 4-10: Illustration of "Total Elevation" in Case D



Quantitative Assessment of Proposed Measures

The results of each of the proposed measures will be assessed from the perspectives of the amount of modal shift and the amount of reduction in fuel consumption in first and second sections, respectively.

Calculating the amount of modal shift

The amount of modal shift was estimated through the following process:

1. An OD (origin–destination) zone is selected as the subject for modal shift.
2. The benefit for the BRT user when each measure is implemented is calculated. To this end, a table of operation times is produced for cases where each measure is implemented with respect to the current BRT operation situation analyzed in section 3; and factors such as the shortening of trip times required for travelling within each OD are calculated.
3. Based on the result of item 2, the utility function derived in chapter 3 is used to calculate the amount of modal shift.

The traffic heading toward central Jakarta from the vicinity of Kalideres Station and the extended stations in the morning is envisioned as the subject for modal shift, among the traffic passing through Daan Mogot road along Corridor 3. Hence, as shown in Figure 4-11, the regions of around two kilometres from the vicinity of Kalideres Station and the extended stations have been selected as the target origin zones. The regions within a radius of two kilometres of Corridor 1 and Corridor 9 stations in central Jakarta have been selected for the destination zones. The amount of traffic passing along the Daan Mogot road was determined from the result of traffic assignment based on the JUTPI[2] traffic data for 2010 (Figure 4-12).

[2] Jabodetabek Urban Transportation Policy Integration.

Figure 4-11: Selected Origin–Destination Zones

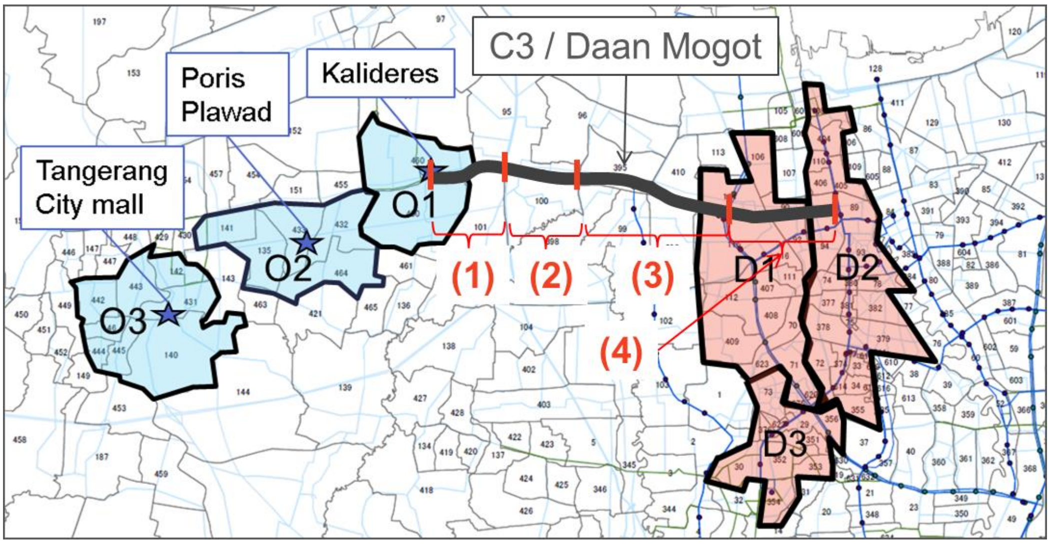
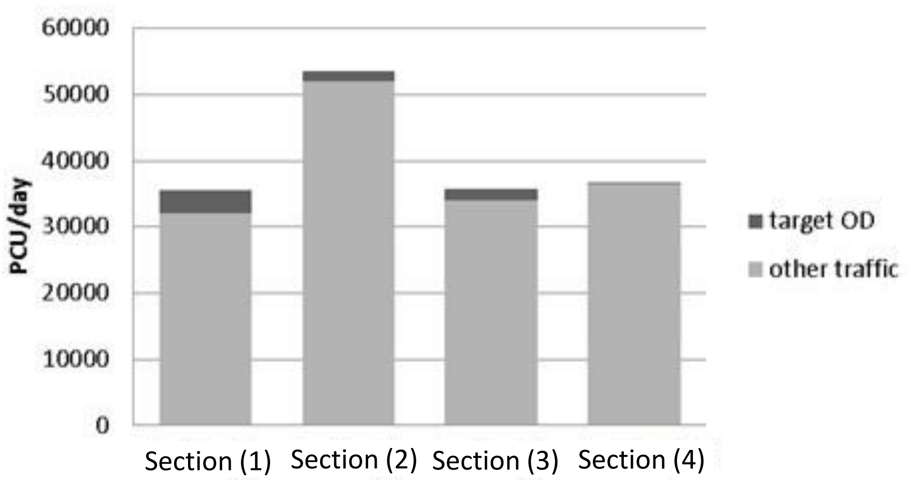
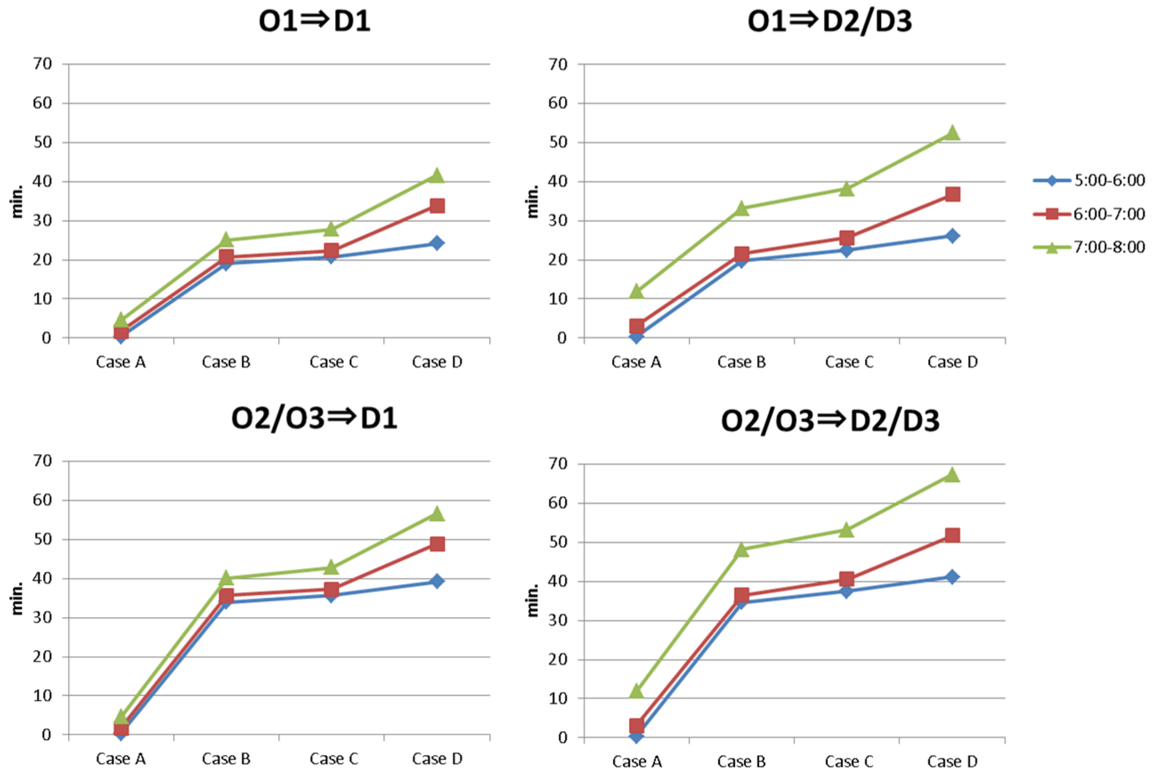


Figure 4-12: Ratio of Target Traffic Amounts in Each Road Section



The reduced trip times when each measure is implemented are shown in Figure 4-13. Regardless of the OD, the trip time is reduced in particular in cases B, C, and D. This is because direct operation is envisioned for these three cases, meaning, a reduction in connection times. The reduced trip time for cases B and C is of the same level, and although dependent on the OD, it is possible to shorten trip times by 20 to 50 minutes. In case D, the trip time can be reduced especially for the morning peak period from 6:00. Depending on the OD, there may even be reductions of 70 minutes. Details of BRT operation schedules produced are shown in Appendix C.

Figure 4-13: Reduced Trip Time for Each Origin–Destination



Note: It is assumed that in cases B, C, and D implementing direct operation, the trip times for users departing O1 would see a reduction in the time spent connecting onto Corridor 1 or Corridor 9 (15 minutes), whilst the trip times for users departing O2 and O3 would see a reduction in connection times at Kalideres Station and onto Corridor 1 or Corridor 9 (each 15 minutes; total 30 minutes).

From the above results, we used the utility function derived from chapter 3 to calculate the rate of modal shift (Figure 4-14). In cases B, C, and D where there was a large reduction in time, the rate of modal shift is high. Although the highest rate of modal shift among cases B, C, and D was found in case D, we see no substantial difference overall. Across all of the cases are particularly high rates of modal shift during the commuting period in the hour from 7 am. In terms of amount of modal shift on Daan Mogot road (Figure 4-15), naturally the largest amount is in case D but no substantial differences are evident between the three cases. Between the three, case B has the lowest costs, and from the perspective of the amount of modal shift, we may regard this as the measure having the most significant benefits with respect to costs. Because the amount of modal shift is large during 7 am to 8 am, it is important when to implement the soft measures envisaged in case B to concentrate on that within this period.

Figure 4-14: Rate of Modal Shift for Each Measure

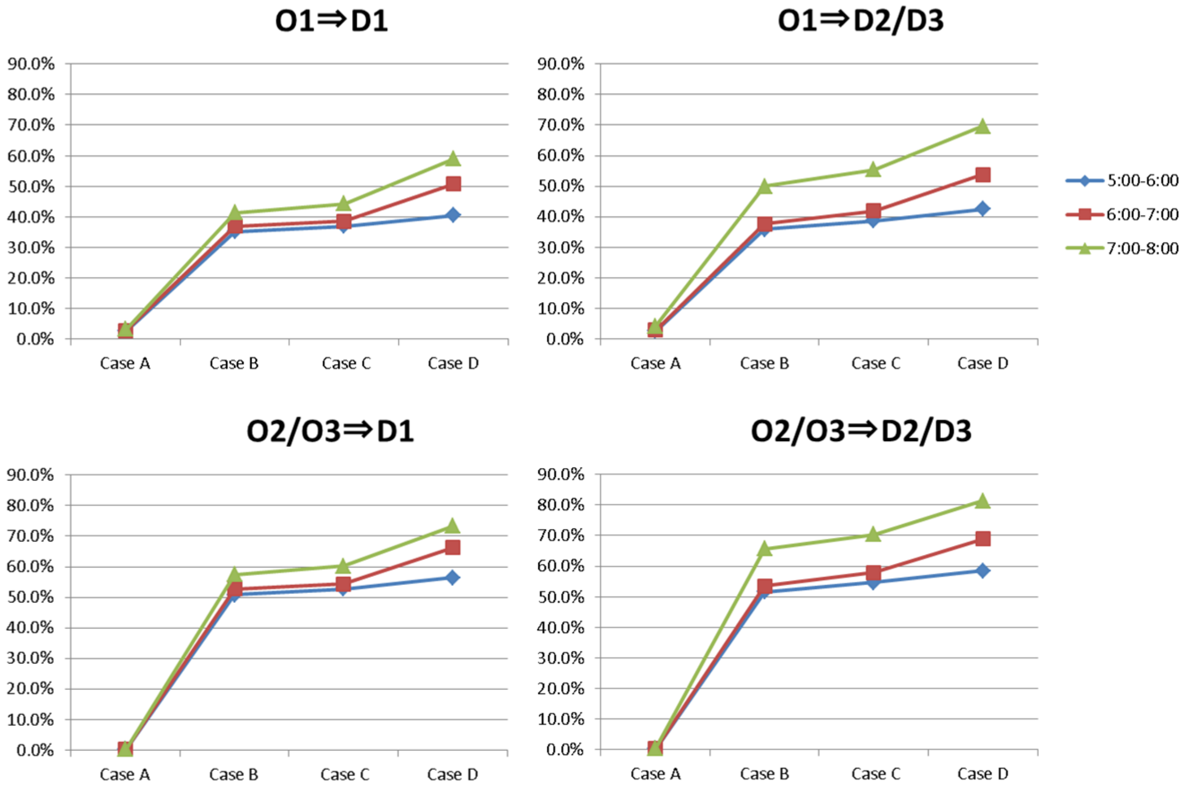
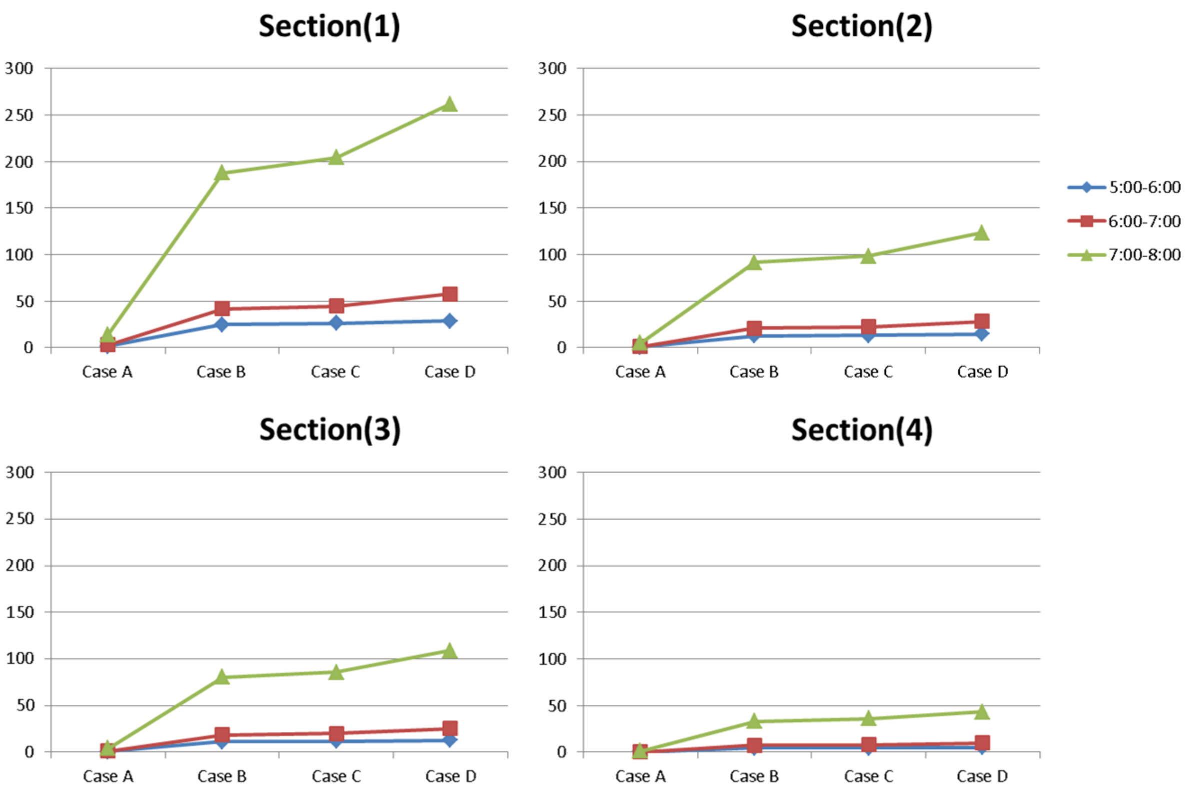


Figure 4-15: Amount of Modal Shift for Each Measure [PCU/h]

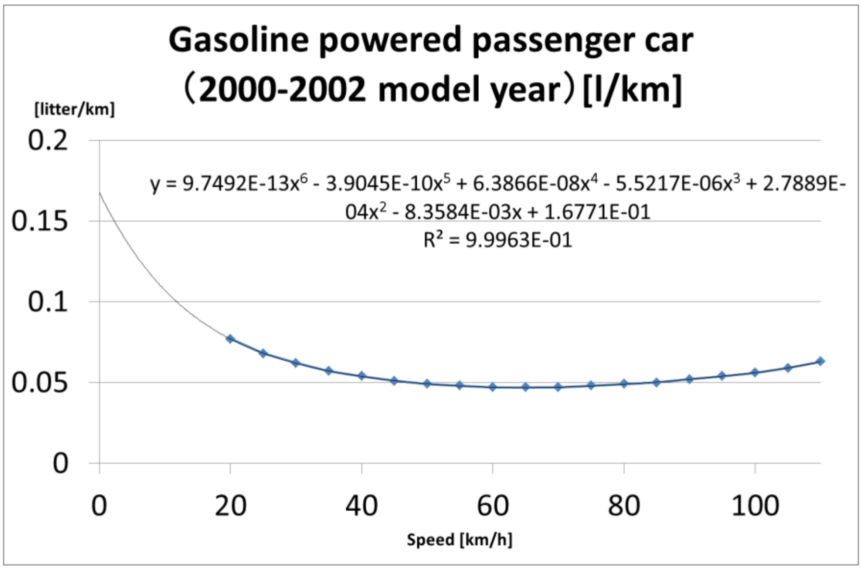


PCU/h = Passenger Car Unit or Passenger Car Equivalent per hour.

Calculating the amount of reduction in fuel consumption

We examined the amount of reduction in fuel consumption by including the direct results of decrease in private transport associated with modal shift and the effects of speed improvement due to the reduction of private transport. For the effects of speed improvement, the increase in speed due to the reduction in private transport was calculated using the BPR function,[3] and the reduction in fuel consumption according to speed was calculated based on the data of the National Institute for Land and Infrastructure Management (Figure 4-16).

Figure 4-16: Rate of Fuel Consumption when Driving an Automobile



Note: Uses a value for speeds less than 20km/h approximated by a polynomial of degree six.

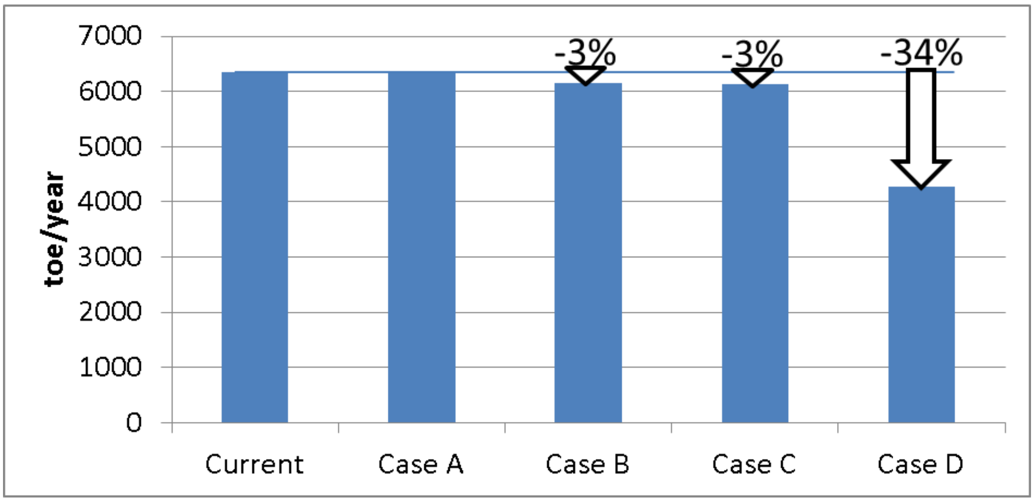
Source: Technical Note of National Institute for Land and Infrastructure Management No. 671, Grounds for the Calculation of Motor Vehicles Emission Factors using Environment Impact Assessment of Road Project, etc. (Revision of FY 2010), http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0671.htm

The results of decreased fuel consumption are shown in Figure 4-17. The largest effects were in case D, with a reduction of 1.0 ktoe/year. This results in a reduction of approximately 34 percent from the original amount of fuel consumed. The 'soft' measures of case B had a similar decreasing effect as

[3] The Bureau of Public Roads developed a link (arc) congestion (or volume-delay, or link performance) function.

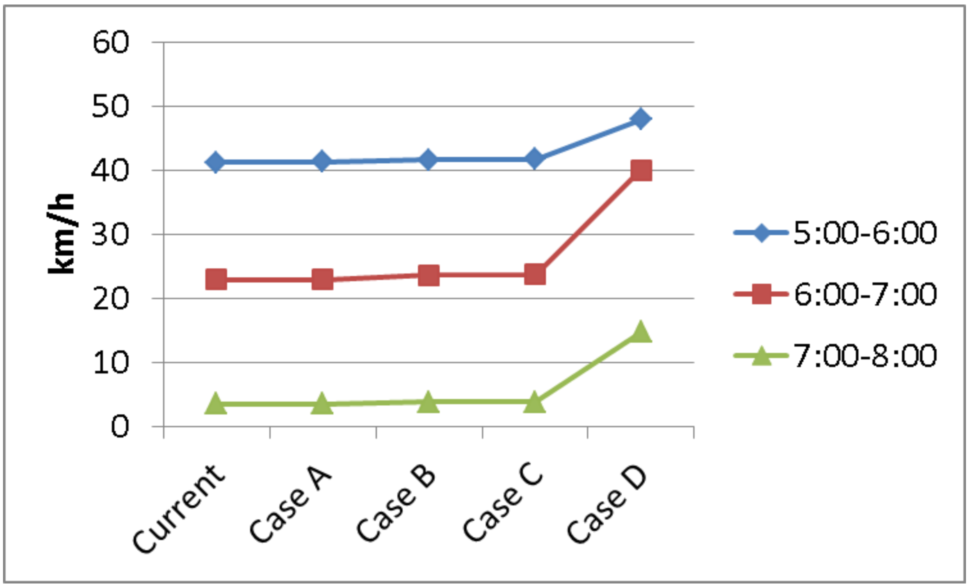
case C which includes some 'hard' measures, at 0.1 ktoe/year. Case A had the least effects compared with the other measures. The reason for the substantial decreasing effects in case D lies in the drastic improvement in the speed of private transport (Figure 4-18). Since the BRT-dedicated lane was converted into a lane for private transport, the speed of the latter improved, resulting in improved fuel economy.

Figure 4-17: Amount of Fuel Consumption Reduction for Each Measure



Note: The amount of decrease in fuel consumption for a year was approximated by taking the effects for three hours in the morning, multiplying this by two due to a similar effect during the evening peak, and multiplying this by 365 to get the annual amount.

Figure 4-18: Average Speed for Private Transport



What degree of effects would we expect if these measures were applied to all 12 corridors in Jakarta? Based on the results on Corridor 3, we get approximately 24.8 ktoe/year decrease in fuel consumption with case D, and approximately 2.3 ktoe/year with case B.[4] These are equivalent to approximately 1.3 percent and 0.1 percent, respectively, of the gasoline consumption in Jakarta, of 1.92 Mtoe/year.[5]

Looking forward, there are plans to increase the number of BRT routes. For example, a plan has been proposed in JAPTraPIS to increase the number of corridors to 30 by 2020. If case B or case D were to be adopted in all these 30 corridors, we could anticipate decreases in fuel consumption of 3.8 ktoe/year and 41.3 ktoe/year, respectively.

[4] Based on the effects of decreasing fuel consumption on Corridor 3, the amount expected by application to 12 corridors was estimated by multiplying by 12.
[5] Approximated from the 2013 ERIA working group data, given the product of the amount of fuel consumption in Jakarta in 2009 of 200 toe/1000 persons, and the city's population in 2010 of 9.6 million.

Figure 4-19: Decrease in Fuel Consumption if Applied to 12 Corridors

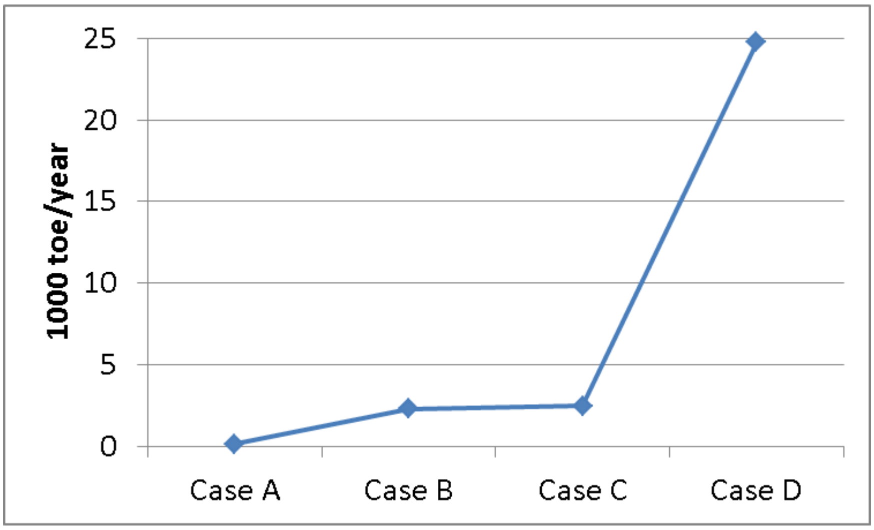
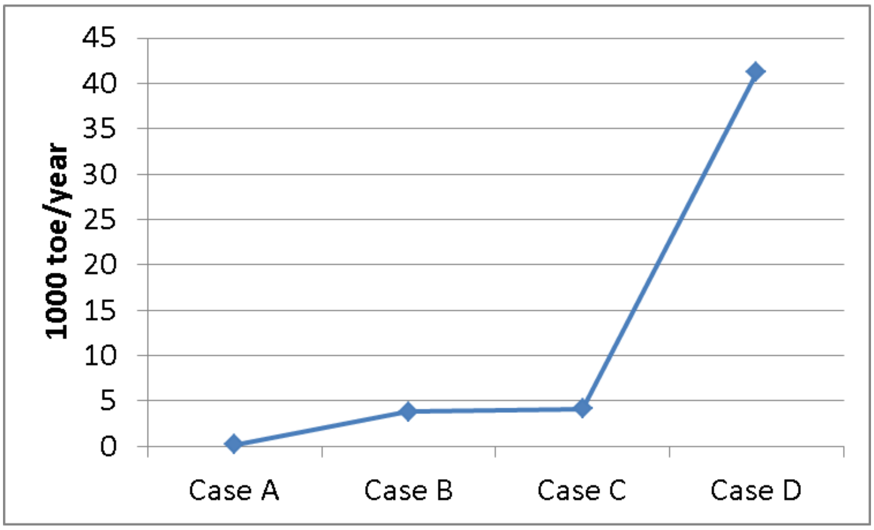


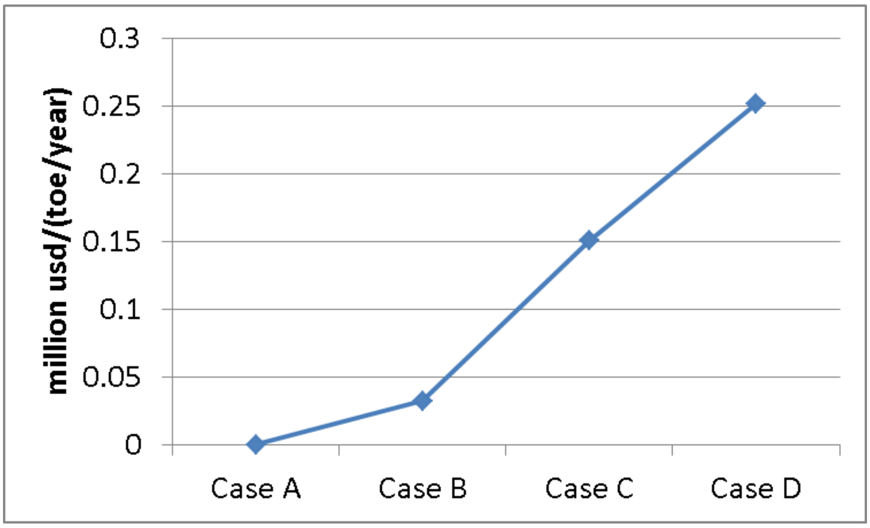
Figure 4-20: Decrease in Fuel Consumption if Applied to 30 Corridors



Cost and benefit balance

The challenge here is the expectation that the costs will be higher and more time will be required for implementing case D than the other measures. As an alternative option to case D, if those with the next highest effects in fuel consumption decrease, cases B and C, are compared in terms of cost performance (Figure 4-21), then case B would appear to be cheaper. Accordingly, whilst efforts are made to implement case D as soon as possible, it is desirable to pursue case B as an interim measure until the former starts to be implemented. Although case B is worse than case D in terms of the amount of decrease in fuel consumption, around 80 percent of the amount of modal shift of case D can be expected. Thus, by implementing case B in advance of case D, perhaps the foundation can be created for modal shift. Meanwhile, in order to discuss the cost performance accurately, it is necessary to consider the O&M (operation and maintenance) cost, attainable benefits other than decrease in fuel consumption, such as economic effects.

Figure 4-21: Cost Required for a Decrease in Fuel of 1toe/yr



Discussion

From the above analyses, we learned that the effects of decreasing fuel consumption were highest for case D. This is a measure that completely segregates private transport and the BRT to achieve faster speeds on both modes of transport. In this sense, case D may also be perceived as a measure that replaces the BRT with the MRT (metro or train). Because the MRT has a higher transport capacity than the BRT, it would appear to be more appropriate as a key transport system in cities with large traffic volumes. Based on the current situation in Jakarta, that of extremely high traffic volumes and severe congestion, we assume a sequential change from roads to the MRT is required.

Our examination in this chapter produced results suggesting that for each measure in cases B, C, and D, the rates of modal shift for the target OD are high at over 40 percent (Figure 4-14). On the other hand, the target ODs account for only a small proportion of the overall volume of traffic (Figure 4-12). Taken as a whole, the modal shift effects are somewhat limited. This means that for the total traffic in Jakarta, the ratio of coverage for the existing

BRT route network is low, and the number of potential BRT users itself is small. If the number of potential BRT users could be increased by further expanding the BRT network and developing housing in the vicinity of BRT stations, for example, and the measures proposed in this chapter are then applied, better results could be anticipated.

Key Findings

In this chapter, we used GPS tracking data to analyze actual bus operation. By so doing, we confirmed that the current operation status varies from day to day, making it difficult for users to forecast their travel times using the BRT. We specified places where the problems are caused, and deduced that these were sections that require focused improvement. By analyzing actual operation data in this way, it becomes possible to elicit the specific challenges to advance modal shift, and propose concrete solutions.

We then made a comparative assessment of the proposed measures. Various levels of measure were examined, and the following proposals were made to enhance modal shift.

1. The number of routes should be increased and a transport plan coordinated with residential planning should be implemented to increase the coverage rate of public transport. This is the foundation for improving the efficiency of all kinds of modal shift.
2. It is necessary to completely segregate public and private transport on roads and routes where the traffic load is concentrated. Doing so could maximize the benefits of public transport and encourage modal shift, whilst also making the flow of both private and public transport smoother and preventing energy waste. In Jakarta, we propose the sequential change from BRT to MRT for routes with high traffic volumes. If this were applied to the whole of Jakarta (12 corridors), then a decrease in 24.7 ktoe/year, or 1.29 percent, of gasoline consumption could be expected.
3. Until the above measures are set in place, efforts should be made to improve operation by, for example, introducing express and direct services for the BRT. Although these measures have comparatively

small effects in decreasing fuel consumption compared to the other measures above, the effects in terms of modal shift are substantial. Accordingly, this would appear to be a key move for increasing the modal shift effects when implementing large-scale measures like the MRT. We propose that express services, direct operation, and extension of routes be implemented in Jakarta; in addition to a strengthening of restrictions of private transport inflow into dedicated lanes. If these could be implemented for the whole of Jakarta (12 corridors), then a decrease in 5.7 ktoe/year, or approximately 0.3 percent, of gasoline consumption could be expected.

Measures for expanding public transport, such as items 1 and 2 above, must be executed in a way that is compatible with the rate at which traffic demand is increasing. However, further expansion of the BRT and the MRT in large cities like Jakarta, where traffic demand and chronic congestion are already extremely high, is associated with significant difficulties like further exacerbation of congestion caused by the factors below:

- BRT expansion – decrease in the number of car lanes to ensure BRT-dedicated lanes
- MRT construction – temporary interruption of traffic due to construction work, and reduction in the number of car lanes.

To promote modal shift, measures may be considered for making the benefits of public transport outweigh those of private transport due to automobile parking costs, maintenance costs, and adoption of limits on usage and speed. However, measures such as these are difficult to implement under conditions where alternative public transport systems are unable to provide adequate capacity.

Considering these factors, it is clearly necessary to guarantee public transport with sufficient capacity and wide-ranging coverage to preempt the increase in traffic demand in cities that are certain to continue developing in the future. In ASEAN countries, many cities will experience growth going forward. This implies that cities have the potential for rapid increase in traffic demand. By conducting analysis on cities like these, perhaps a more effective discussion aimed at improving the efficiency of energy usage in the transport sector will become necessary and possible.

CHAPTER 5
Policy Recommendations and Next Steps

Policy Recommendations

This study aims to improve energy efficiency in the transport sector, which has been analyzed primarily in terms of improving the automobile traffic situation. In this analysis, we examine existing initiatives and policies developed in countries across the world, and have selected Jakarta of Indonesia as a model city for its case study to undertake a quantitative analysis of the transport situation in the city using a simulation model.
Based on the results of the above analysis, we would like to set out the three following statements as policy recommendations of the study:

1) the need for urban transport to be part of energy policy,
2) the need for comprehensive measures, and
3) the importance of long-term planning.

The need for urban transport to be part of energy policy

Traditionally, discussion on energy saving in the transport sector has centered on increasing the efficiency of mobility itself. This has meant, for example, discussions on increasing the use of automobiles with improved fuel efficiency, such as hybrid and electric vehicles. Yet whilst improved fuel efficiency in automobiles does indeed contribute towards improved energy efficiency in the transport sector, given the enormous stocks of existing vehicles, the effects of such changes are likely to take longer. Moreover, trends in the technological development carried out by automakers or the taste and purchasing power of consumers will affect, and sometimes even limit, its effect.

Meanwhile, the chronic traffic congestion which has become a salient issue in large Asian cities has become another factor pushing up the oil consumption by automobiles. No matter how efficient the automobiles, the actual level of fuel efficiency plummets when drivers are unable to drive at a speed any faster than walking pace.

This means that improving the efficiency of vehicles themselves is not sufficient for improving energy efficiency overall; creating a city where there is no significant traffic congestion enables cities to minimize energy consumption in urban transport.

In addition, the use of the MRT is a crucial element for improving overall energy efficiency in the transport sector. Shifting transportation demand away from private cars and towards the MRT can cut energy consumption, particularly in the central areas of large cities where the demand for transport is high. This reduction comes not only from the fact that the energy consumption per unit of person and per kilometer is lower for the MRT than for automobiles, but also from the fact that the reduction in the number of automobiles on the roads allows the remaining automobile traffic to move more smoothly.

As set out above, improving the urban traffic situation is essential for improving the energy efficiency of the transport sector. In other words, this means widening and extending roads to meet transportation demand, improving those transportation intersections which appear to be causing congestion, and developing MRT infrastructure such as subway systems.

One area that needs to be discussed is the question of whether the energy efficiency policies that have been developed up to now in the region have been properly connected with urban traffic issues. In most countries, the ministries for energy and for transport are separate; in many cases, insufficient countermeasures have been developed for the crossover area of these two ministries. What is more, although the domain of urban planning also impacts energy demand in the transport sector (through, for example, policies for locating residential areas close to the places where people work to minimize the demand for transportation itself), it seems that urban planning and transport policy have not been connected sufficiently. Awareness of how important it is to resolve urban traffic issues also appears to have been lacking across Asian cities, despite the fact that solving this issue is key for putting energy-saving measures into practice.

As the results of this study show, raising the energy efficiency of the transport sector is closely bound with improving the urban traffic situation, and neither of the two can be considered in isolation from the other. It is important to think of urban traffic issues as an essential component of energy issues, and to set out appropriate policies for dealing with them.

The need for comprehensive measures

Developing a ‘comprehensive policy package’ is essential if cities are to improve energy efficiency in the transport sector. The key phrase, ASIF or Avoid–Shift–Improve–Finance, can be used to break down such multilayered policy measures.

‘Avoid’ refers to measures which are developed from the urban planning stage for minimizing transport demand itself. ‘Shift’ describes measures which functions to shift traffic from automobiles towards the MRT such as rail and bus. ‘Improve’ refers to measures that improve the fuel efficiency of automobiles themselves. ‘Finance’ describes measures which aim to provide the funding necessary for making all of the above measures a practical reality.

Improving the accessibility of public transport is crucial for achieving the ‘Shift’ policies which are the subject of the analysis carried out this year. In concrete terms, it is easier for people to use public transport if they are able to reach a railway station or bus stop in 10–15 minutes on foot or by bicycle. To make this a reality, it is essential to develop/extend a dense network of public transportation and create an environment that allows people to walk to the relevant facilities in comfort.

At the same time, it is also important to make public transportation more attractive as a means of transit. One point that became clear from this case study was that the length of travel time exerts considerable impact on consumers’ choice of the mode of transport. In addition, since economic feasibility is obviously also an important factor, making public transport more attractive in terms of cost compared to using automobiles will also be effective in boosting use, provided that prices are set at a level ensuring that the system can still be run sustainably.

Finally, the role played by finance cannot be ignored. Although as a general rule the funds required for transport projects are procured exclusively from individual countries or companies, in some cases it can be difficult to procure all the necessary funds from such sources due to insufficient credit capacity relative to the level of investment required. In such cases, involving an international financial institution which seeks to realize national and regional development as its objective can provide considerable momentum to the project. The involvement of an international financial institution not only provides a source of funding but also increases the credibility of the project itself.

In general, operation of public transport systems should be self-sustainable with their own fare revenues. However, if there is a need to keep finances from deteriorating in the initial period following the start of operations, or if it is recognized that lowering fares could be effective in terms of encouraging a shift towards the MRT, the temporary injection of public funds is also one possible option.

Although these measures can function as standalone policies, combining several policies together can make them function better. For example, it is possible to mandate the use of parking lots and raise usage charges as policies for minimizing automobile traffic; however, unless such measures are accompanied by the provision of public transport which can be used instead of automobiles, the volume of automobile traffic is unlikely to decrease. By contrast, providing relatively inexpensive public transport (subways, buses, etc.) as a substitute for automobile travel at the same time as introducing parking regulations for automobiles can greatly encourage a reduction in the use of automobiles and a shift towards public transportation.

This should make it readily evident that it is vital to introduce a number of policies at the same time to increase the effects that each policy aims at. The challenge here is the issue of organisation. Entities responsible for energy policy and entities responsible for transportation/urban planning both need to work together in formulating and executing ASIF policies. Central and regional governments also need to work together on these issues. Given the considerable length of such partnerships and the difficulty in coordinating them, such projects need to be driven forward under robust leadership, inclining towards the top–down style.

Table 5-1: Policy Options under the ASIF Approach

Avoid	To reduce travel demand by integrating land use planning and transport planning to create city clusters that require less mobility and reduce transportation demand.	・vehicle registration fees/tax ・license plate fees ・mandatory vehicle insurance ・road pricing ・parking fees
Shift	To utilize alternative modes of transport, such as MRT systems, rather than passenger vehicles. Mass transit systems include buses, rails, and subways, where energy use/CO_2 emissions per passenger/kilometre are theoretically lower than those of passenger vehicles.	・MRT systems ・BRT systems ・improving feeder bus services ・improving multi-modal transfer through comprehensive tariff structures
Improve	To upgrade the overall efficiency of urban transport through vehicle efficiency based on technological innovations, policy measures to manage road traffic, and the use of information technology.	・Fuel economy improvement ・Alternative vehicles (electric, compressed natural gas [CNG], and fuel cell vehicles) ・intelligent transport systems ・incentives or regulations
Finance	To offer a monetary base for developing and improving transport-related systems. Various taxes are available as possible	・fuel tax ・congestion pricing

	options, and the revenues can be allocated to road improvement or upgrading public transport.	▪ environmental tax ▪ vehicle registration taxes ▪ license plate bidding ▪ parking fees

c. The importance of long-term planning

Looking at case studies from Asia’s major cities, it appears that the demand for transportation grows rapidly once cities are at the certain stage of economic growth and urban development. Transportation demand is increasing at a rate that is outstripping the formulation of policies and development of infrastructure, resulting in considerable traffic congestion in cities, energy wastage, and even economic losses.

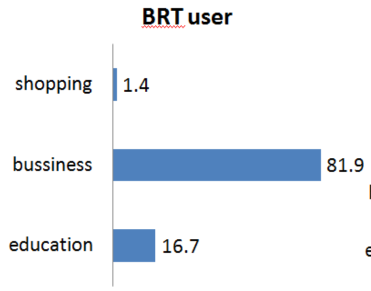
It is reasonable to suggest that one factor behind this is that cities have been overly optimistic in projecting future developments in their traffic situation, and have lagged behind in terms of policy formulation and planning. For example, given how long it takes to build large-scale roads and develop subway systems, it is obviously not good enough for cities to wait until the situation has become critical and then try to deal with the problems through stopgap measures. Rather, cities need to look ahead to the kind of changes that are likely to take place in the future, and put preventive measures in place to ensure that the situation does not become intolerable. As preventive measures, such policies bring few immediate benefits and may face considerable opposition at the time when they are decided. Nevertheless, as transportation/urban planning are intimately bound with energy consumption, it is absolutely vital that they are approached from this kind of long-term perspective. Needless to say, the formulation and execution of long-term plans are also elements which are impossible to bring about without strong leadership.

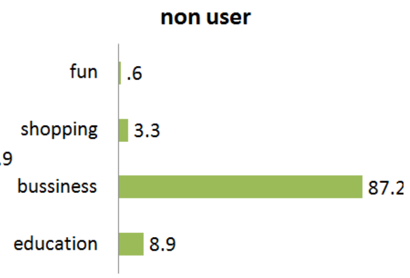
More precisely, cities need to draft step-by-step plans and measures, and set out timelines for putting these into action. For example, rails and subways have the advantages of high transportation capacity and high speed; these also require considerable initial investment and carry major risks if the projected numbers of passengers are miscalculated. Given this, the BRT, which uses existing road infrastructure and which can be introduced relatively quickly and at relatively low cost, can be an attractive mode of public transport infrastructure for the short to medium term. For this reason, one suggestion is to introduce the BRT initially as a stopgap measure for the short to medium term, and then bring in rail transit later on as the number of passengers increases. However, in large cities such as Jakarta whose entire metropolitan area houses a population of around 10 million people, it makes more sense to move forward with developing rail transit at an early stage, since it is self-evident that the BRT alone will not be able to cover passenger demand in a city of this size.

APPENDIXES

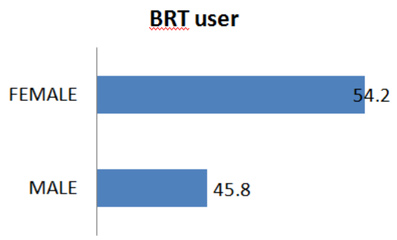
Appendix A. Chapter 3, Supplemental Survey Result

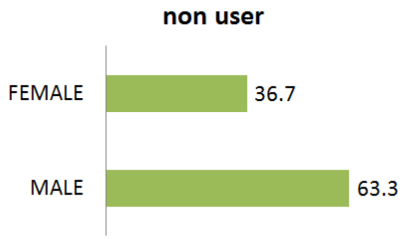
1. Travel Purpose



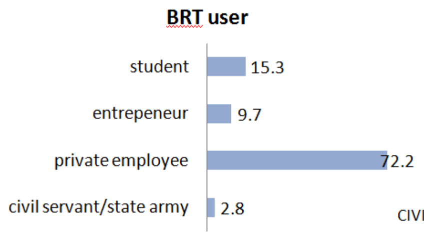


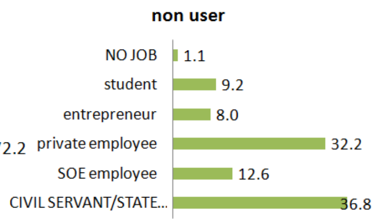
2. Gender



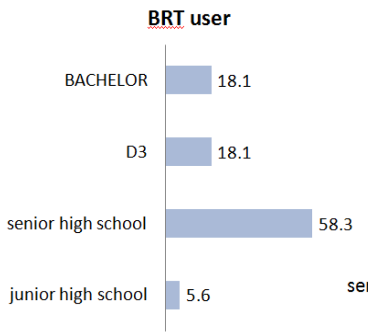


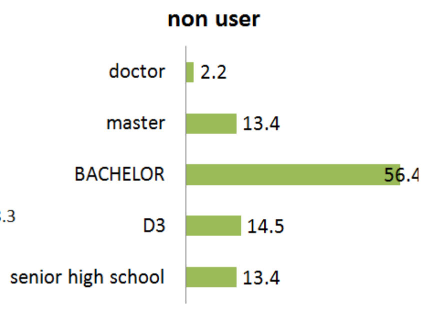
3. Job





4. Education



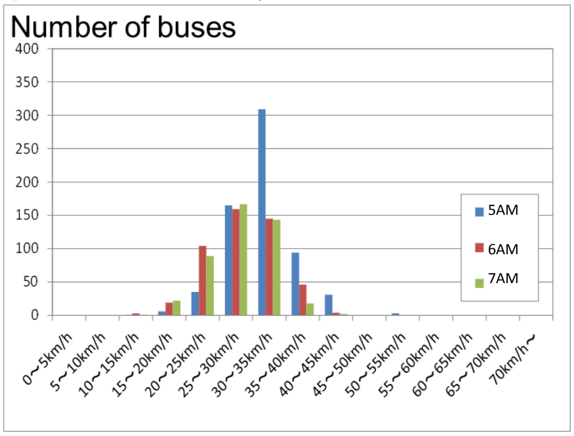


Appendix B. Chapter 4, Details of BRT Operation Analysis

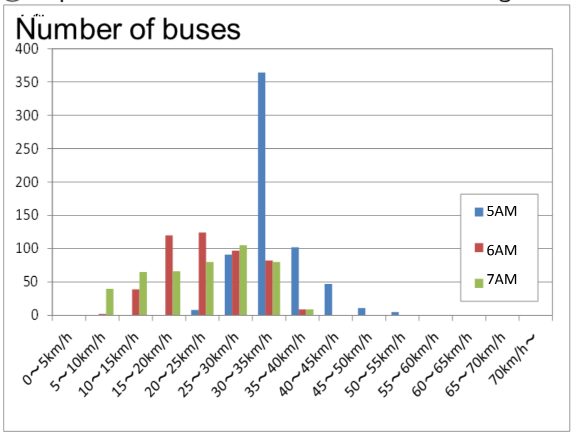
Here we will provide details of the average speeds between each pair of stations obtained as the result of more detailed analysis of the GPS tracking data for the BRT. In general, operation speeds are not stable, and from 7 am onwards on weekdays in particular, there are many sections where substantial dispersion is evident.

Figure B-1: Distribution of Number of Days for Average Speed between Pairs of Stations on Weekdays

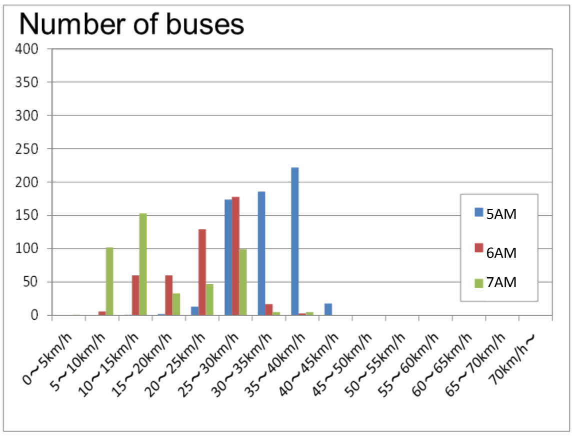
⑤Jembatan Baru—Dispenda Samsat Bara



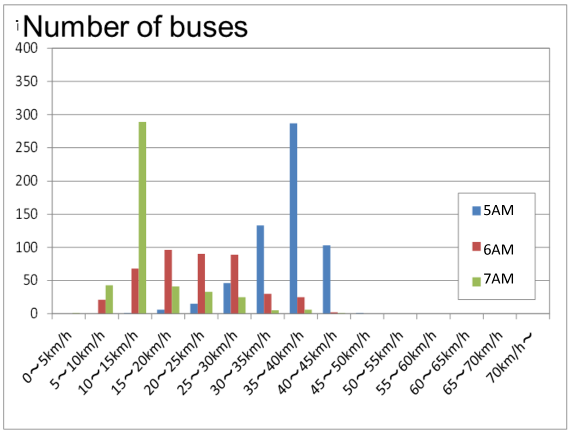
⑥Dispenda Samsat Bara—Jembatan Gantung



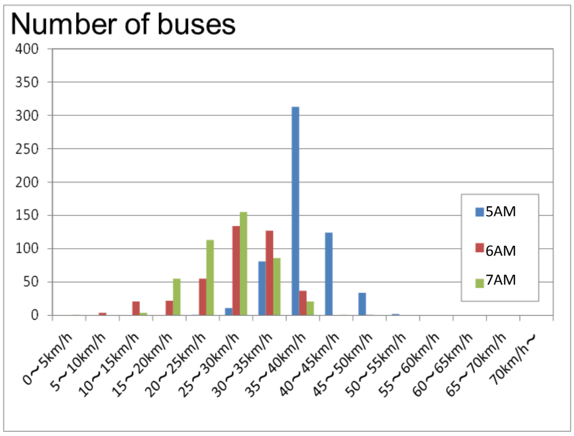
⑦Jembatan Gantung—Taman Kota



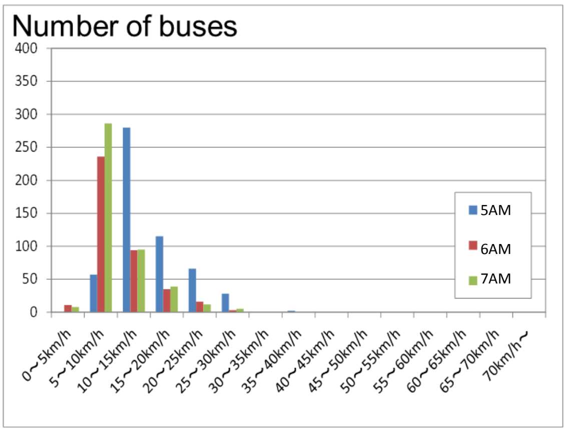
⑧Taman Kota—Indosiar(no dedicated lanes)



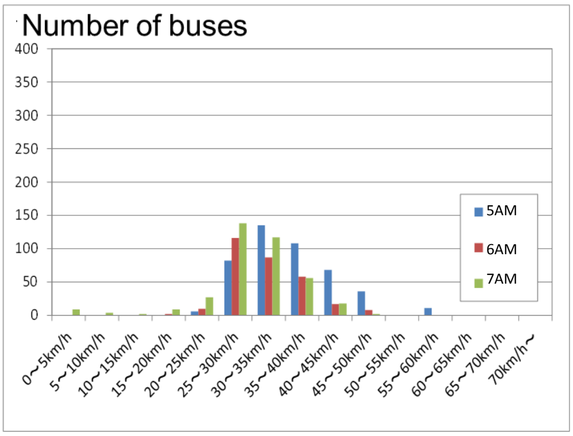
⑨Indosiar—Jelambar



⑩Jelambar—Grogol



⑪Grogol－RS.Sumber Waras



⑫RS.Sumber Waras－Harmoni

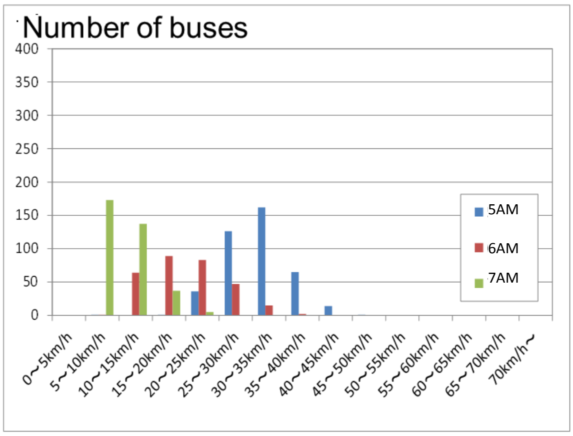
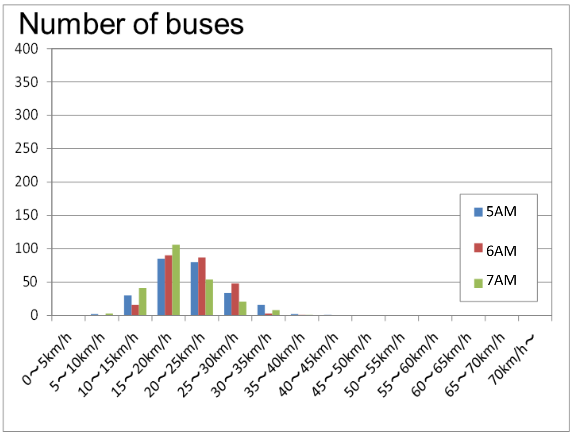
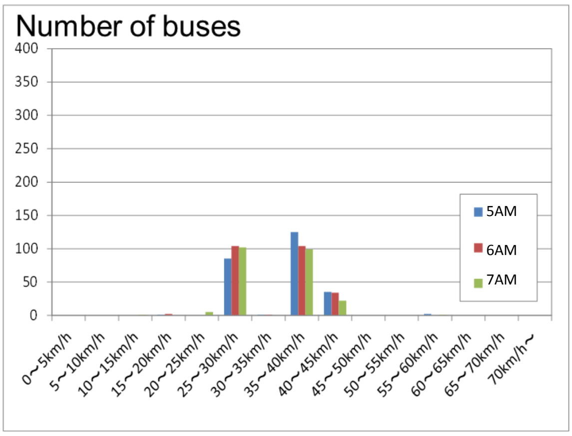


Figure B-2: Distribution of Number of Days for Average Speed between Pairs of Stations on Holidays

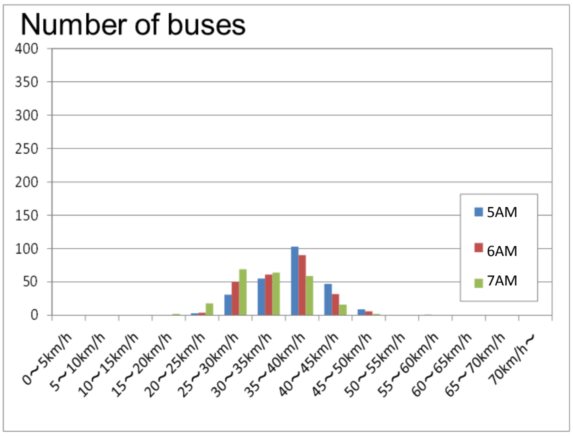
①Kalideres－Pesakih



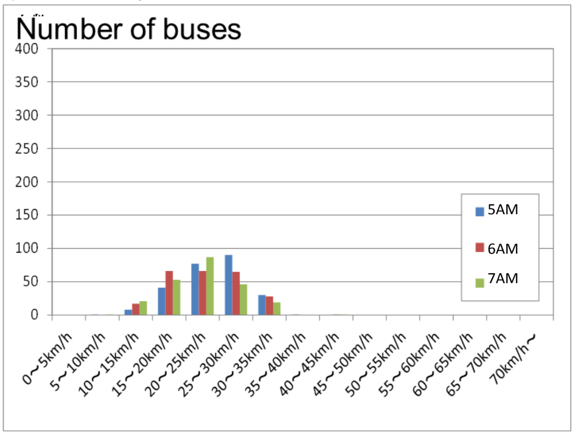
②Pesakih－Sumur Bor



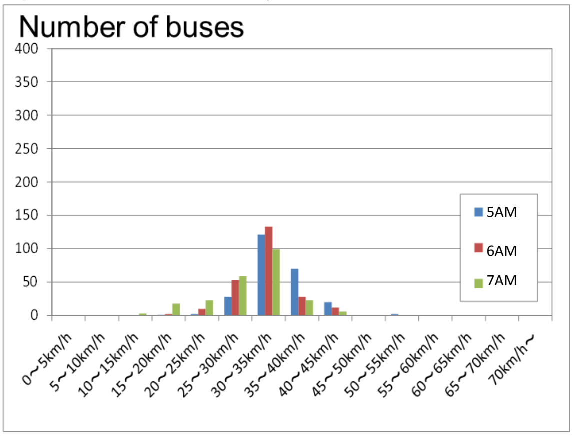
③Sumur Bor－Rawa Buaya



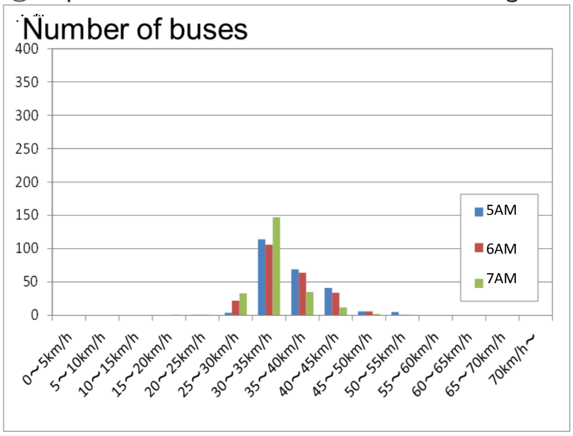
④Rawa Buaya－Jembatan Baru



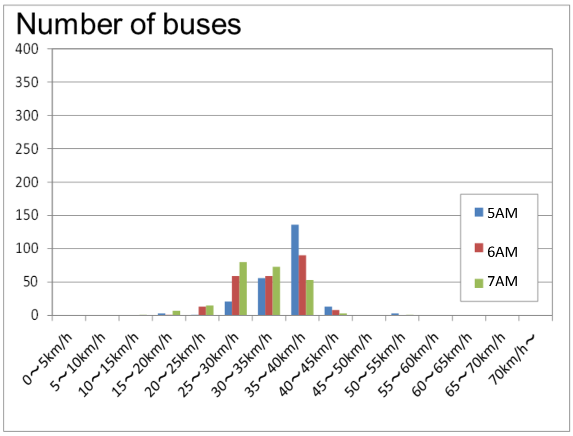
⑤Jembatan Baru－Dispenda Samsat Bara



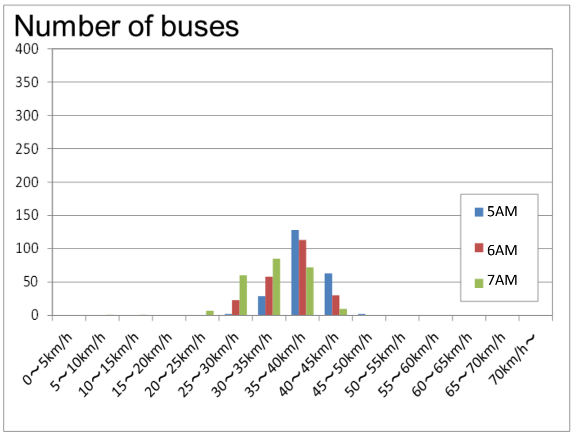
⑥Dispenda Samsat Bara－Jembatan Gantung



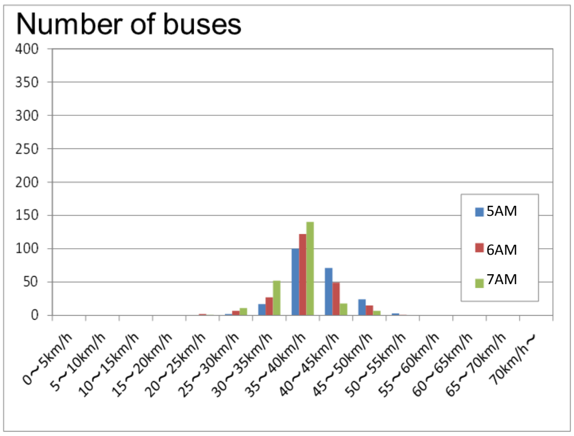
⑦Jembatan Gantung－Taman Kota



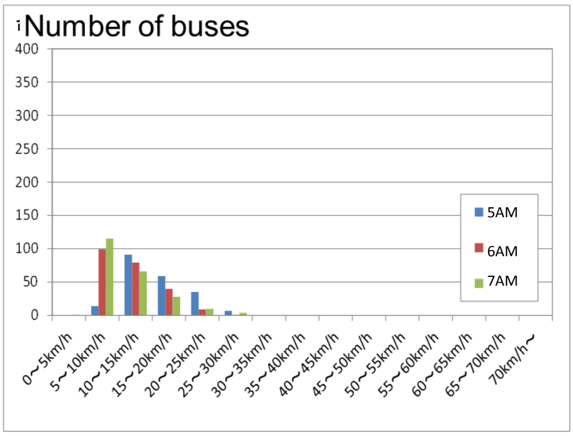
⑧Taman Kota－Indosiar(no dedicated lanes)



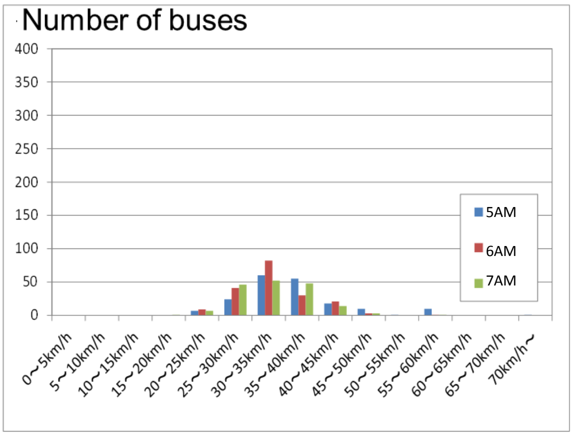
⑨Indosiar－Jelambar



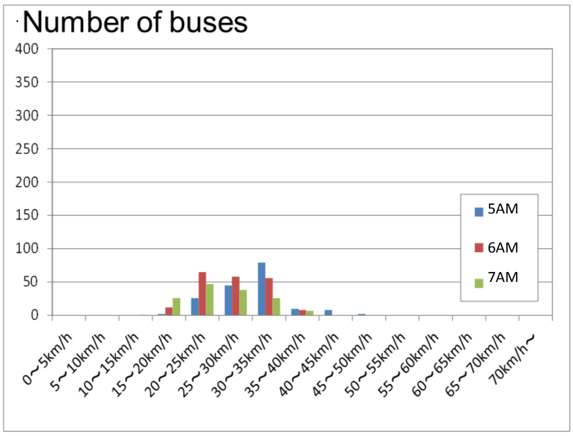
⑩Jelambar－Grogol



⑪Grogol－RS.Sumber Waras



⑫RS.Sumber Waras－Harmoni



Appendix C. Chapter 4, Details of Costs of Each Measure

Details of the cost estimation for each measure are shown in Table 2. Land acquisition costs and operation costs are not included in these estimates.

Calculations are made using 1 IDR = 9/100,000US$.

Table C-1: Details of Costs of Each Measure

	Case A	Case B	Case C	Case D
Contents	Tighter regulation for inflow	A +Express+Extension	B + partial Overpass	All elevation of BRT lane
Infrastructure type and cost	0	Articulated buses 4.97M US$ • 355k US$/bus • 54 buses (40 buses were already installed in 2013) BRT shelter 1.08M US$ • 12000M US$/shlt • 1shelter (Tangerang city mall) Passing lane 0.11M US$ • 2M IDR/m • 200m, 3 points	Cost of B 6.2M US$ Overpass 24.3M US$ • 300M IDR/m • 200m/point, 2points • 500m/point, 1point	Articulated buses 4.97M US$ BRT shelter 1.08M US$ Elevation of C3 513 M US$ • 300M IDR/m • 19km
Total cost	0	6.2M US$	30.5M US$	519.1M US$

Appendix D. Chapter 4, Operating Timetables for Each Measure

Operating timetables produced for each measure are shown below. The current operating tables were based on the average times between each station and the average stoppage times at all stations on weekdays derived from the GPS data analysis.

Operating tables for when measures are implemented were produced based on the current operating tables, with the assumptions of an improvement in the weekday-level speeds on sections where inflow restrictions have been strengthened, and an improvement to the average speed on sections where the infrastructure has been enhanced to 40km/h. Express buses are assumed to operate at a speed 10 percent faster than normal buses. In the measures implementing express services, three additional locations are assumed possible in addition to Dispenda Samsat Bara Station, where an overtaking lane is already in place.

The figures below show express services with red lines, and normal services with black lines.

Figure D-1: Operating Table for Current Case

service
・regular

Service number

	regular	express	total
5am-6am	35	—	35
6am-7am	30	—	30
7am-8am	20	—	20

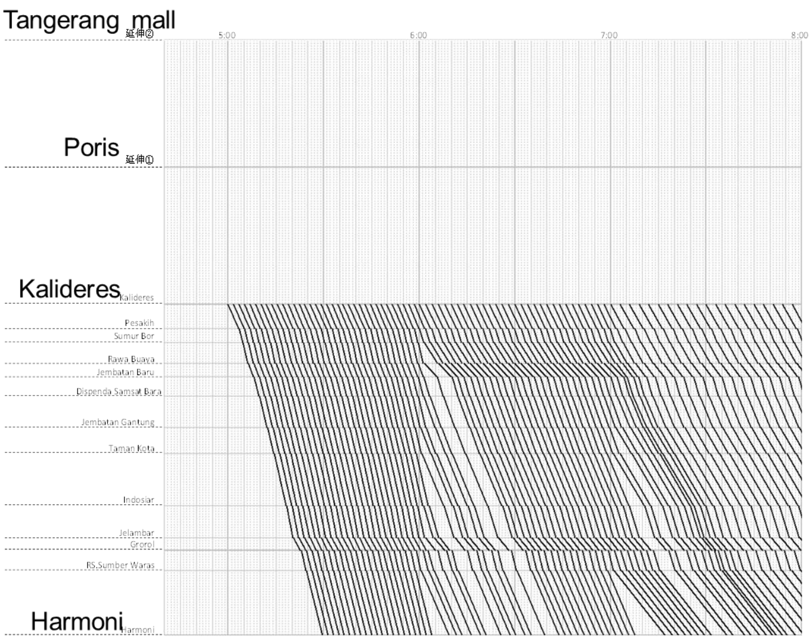


Figure D-2: Operation Table for Case A

service

・regular (better headway)

Additional passing lanes

- nothing

Service number

		regular	express	total
5am-6am		25	—	25
	first half	10	—	10
	Last half	15	—	15
6am-7am		35	—	35
7am-8am		28	—	28

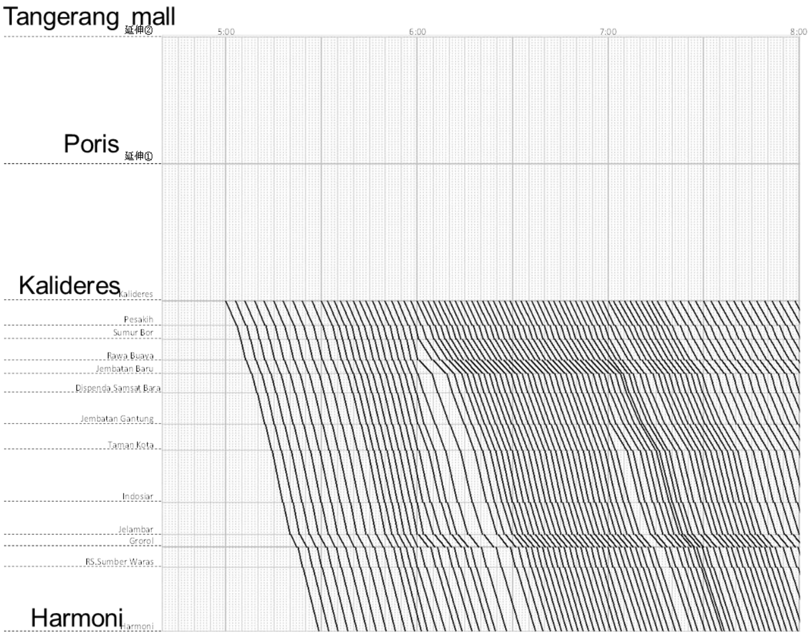


Figure D-3: Operation Table for Case B

service

・regular

・extension+express

Additional passing lanes

- Rawa Buaya,
- Taman Kota,
- Jelambar

Service number

		regular	express	total
5am-6am		18	7	25
	first half	7	3	10
	Last half	11	4	15
6am-7am		18	17	35
7am-8am		18	11	39

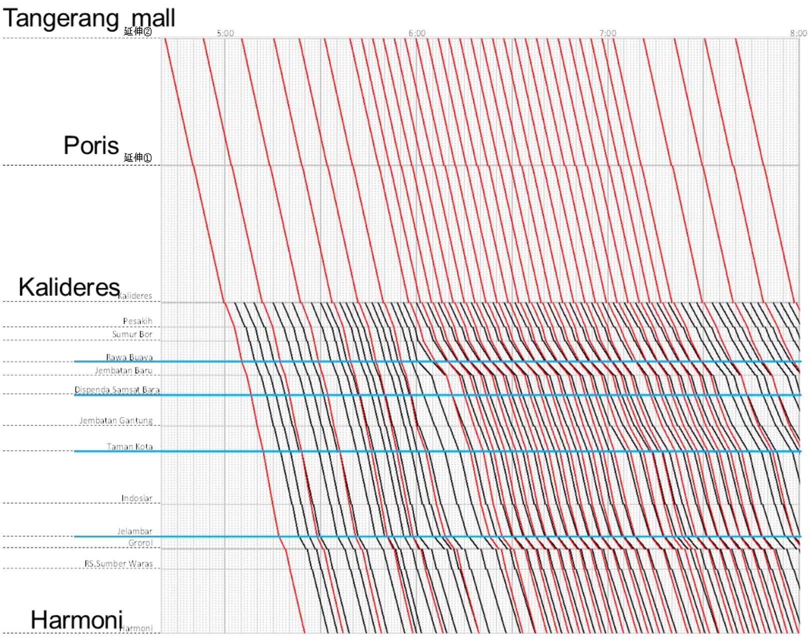


Figure D-4: Operation Table for Case C

service
- regular
- extension+express

Additional passing lanes
- Rawa Buaya,
- Taman Kota,
- Jelambar

Service number

	regular	express	total
5am-6am	18	7	25
first half	7	3	10
Last half	11	4	15
6am-7am	18	17	35
7am-8am	18	12	30

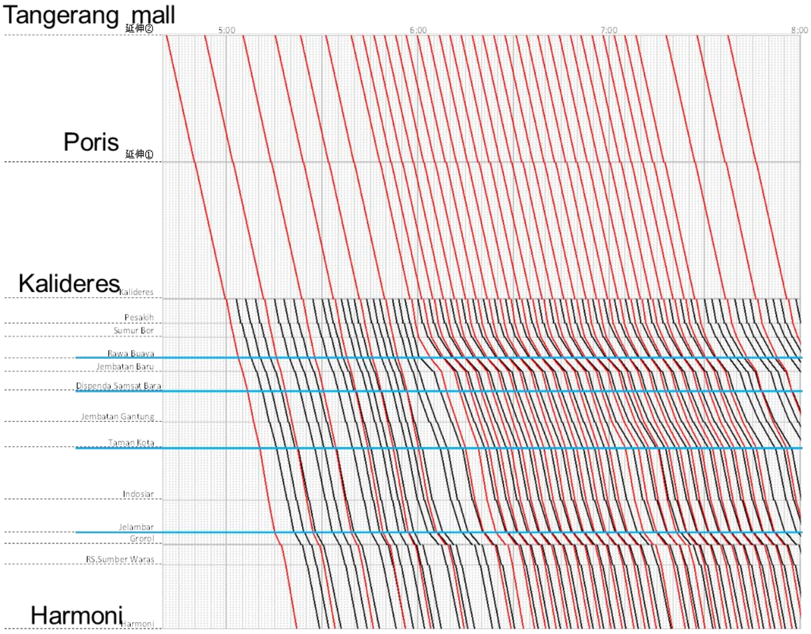


Figure D-5: Operation Table for Case D

service
- regular
- extension+express

Additional passing lanes
- Taman Kota,
- Jelambar

Service number

	regular	express	total
5am-6am	18	7	25
first half	7	3	10
Last half	11	4	15
6am-7am	18	17	35
7am-8am	18	14	32