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Addressing Energy Efficiency in the Transport Sector through Traffic Improvement

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This report was prepared by the working group on 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 Energy Project. Members of the working group, who represent the participating East Asia Summit countries, discussed and agreed to use certain data and methodologies to assess efficiency improvements in the transport sector. These may differ from the data and methodologies normally used in each country. Therefore, the modelling results presented here should not be viewed as official national analyses of the participating countries.

PREFACE

Coping with increasing oil demand is regarded as one of the top policy agendas in East Asia Summit (EAS) countries, since it engenders a variety of concerns for each country, such as a deterioration of oil supply security, fiscal balances, and air quality.

Although several studies have been conducted to address this issue, few have focused on the interrelationship between oil consumption and automobile traffic. This study is unique in that its approach will interconnect energy policy and traffic policy, and quantify the effect of traffic flow improvement on energy efficiency improvement.

The goal of the study is to provide suggestions for policy planners in the EAS region on how to improve energy efficiency in the transport sector.

I hope this study can bring valuable insight for those who are involved in this issue.

Ichiro Kutani

Leader of the Working Group

June 2016

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

ASEAN	Association of Southeast Asian Nations
BRT	bus rapid transit
BRTR	bus rapid transit standard bus
DaCRISS	Study on Integrated Development Strategy for Da Nang City and its Neighbouring Area in Viet Nam
EAS	East Asia Summit
ERIA	Economic Research Institute for ASEAN and East Asia
FY	fiscal year
IC	integrated circuit
IEEJ	The Institute of Energy Economics, Japan
km	kilometre
km/h	kilometre per hour
MRT	mass rapid transit
PPP	public–private partnership

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Executive Summary

Since fiscal year (FY) 2012, research undertaken by the Economic Research Institute for ASEAN and East Asia (ERIA) on the energy efficiency of urban transport in East Asia countries has achieved some success in identifying investment options to reduce traffic congestion, and thus demand for oil. However, it has become clear that the proposed investment and reactive policy measures are likely to be of limited impact and fundamental change is required to achieve a better future for megacities such as Jakarta. This paper focuses on mid- to small-sized cities in their early stage of development, taking Da Nang City in Viet Nam as a case study, and analyses policy and infrastructure measures to prevent future traffic problems and thus avoid excessive energy use in the future.

Possible Improvement in Infrastructure

Da Nang City in Viet Nam plans to develop a bus rapid transit (BRT) system in the near future. However, it does not have a blueprint for a feeder bus system, which is necessary to enable BRT users to access the BRT stations more easily. Establishing a feeder bus system would help increase the number of BRT users and reduce the demand for oil products by private vehicles as a result. This study therefore tackles the design issues of the feeder bus system especially the method for specifying the optimal route of the feeder bus network, assuming transport demand scenarios for Da Nang City in 2017, 2020, 2025, and 2030. The findings are as follows:

- The addition of a feeder bus network increases the rate of public transport use. However, the rate plateaus after reaching a certain investment level.
- The number of BRT users might exceed the planned BRT capacity. Enhancement of public transport capacity should be considered according to projected growth in transport demand in the city.
- The public transport selection rate near the BRT stations is higher than that near the feeder bus network stations (28.5 percent near the BRT station compared with 8.0 percent near the feeder bus network stations).

A public transport preference survey was launched in November 2015 as part of the research and the result indicates that there may be more potential BRT users than anticipated. Insufficient trunk line capacity will have a negative impact on the modal shift, thus the optimal trunk line and feeder line capacity that reflects future situations should be researched in-depth as the next step.

Policy Recommendations

This study also analyses how urban transport efficiency could be improved with more effective policy measures. Drawing on the literature of transport economics, various precedents, cases, and policies throughout the world have been investigated.

The findings indicate that without a strong transport policy, it will be extremely difficult to avoid traffic congestion in a pre-emptive way. This study summarises the key points of transport economics, clarifies the mechanisms that generate urban traffic problems, and reviews a comprehensive methodological framework for dealing with traffic problems. If appropriate preventive measures are taken, then the vicious cycle of economic loss and traffic problems could be avoided. However, pre-emptive measures entail some challenges.

Transport improvement could be addressed through a variety of measures. This study analyses what aspects should be considered and how the combination of the measures could be optimised to improve transport efficiency. The findings indicate that ideal public transport system requires the following fundamental factors:

- A public transport design that balances speed, safety, and comfort considerations
- An excellent operation and management policy that secures the financial stability and competitiveness of the public transport business
- Institutional and political support by government in terms of preferential taxation, regulation, subsidy, and city planning

CHAPTER 1
Introduction

1. Background and Objective

In a series of studies since fiscal year (FY) 2012, the study team has conducted analyses on how to improve traffic flow, and thus energy efficiency in the transport sector, in major cities in East Asia Summit (EAS) region. We selected Jakarta in Indonesia as the subject for a case study. One of the key findings of our two-year study is that appropriate forward-looking investment is required in the initial stage of urban development. For instance, in Jakarta, traffic congestion has deteriorated considerably, and measures to improve such a situation are limited. It also requires greater change in the existing system and massive short-term investment.

The EAS region has many other mid- to small-sized cities that are about to launch or have just launched explosive urbanisation and motorisation. From the initial development stage of the city, appropriate measures must be implemented gradually to allow these cities to develop sound urban transport systems.

In this light, as a continuation the study conducted in FY2014, our case study in FY2015 targets a mid- to small-sized city in its initial development stage, and analyses policy and infrastructure measures for improving traffic and consequently energy efficiency. From this analysis, we aim to derive policy recommendations applicable to many similar cities in the EAS region.

2. Rationale

The rationale of this study is derived from the 17th meeting of the Energy Cooperation Task Force, held in Phnom Penh, Cambodia on 5 July 2012. At this meeting, the Economic Research Institute for ASEAN and East Asia (ERIA) proposed and explained new ideas and initiatives for EAS energy cooperation, including strategic use of coal, optimum electric power infrastructure, nuclear power safety management, and smart urban traffic.

The participants of the meeting exchanged views and agreed to commence proposed new studies. As a result, the ERIA formulated a working group for the ‘Study on energy efficiency improvement in the transport sector through transport improvement and smart community development in the urban area’. Members from Indonesia, Japan, the Philippines, and Viet Nam are represented in the working group, and the Institute of Energy Economics, Japan (IEEJ) acts as the group’s secretariat.

3. Work Stream

In FY2014, we undertook the following five steps.

(i) Selection of the model city:

We selected Da Nang City in Viet Nam as the subject of the case study in view of the condition of the city's road traffic and transport infrastructure conditions, and data availability for the analysis.

(ii) Analysis of policy implementation in accordance with a development stage:

While various policies can be effective at improving traffic (and saving energy consumption), appropriate policies differ depending on the stage of urban and transport system development. Therefore, we analysed the suitability of policies for the development stage in the model city.

(iii) Preliminary simulation analysis for traffic improvement and its effect:

We analysed quantitatively any increase in energy efficiency through the improvement in traffic. In this phase, we focused on developing a new model that can simulate an effect of feeder-line bus development.

Based on the achievements in FY2014, in FY2015 we expanded and deepened the study on energy efficiency improvement in the transport sector as follows.

(iv) In-depth simulation analysis for traffic improvement and its impact:

We conducted in-depth simulation analysis using the model mentioned in step (iii). The analysis was expected to identify possible improvements in traffic flow and quantify their effect on reducing oil demand.

(v) Derive policy recommendations:

Based on the analysis, we derived policy recommendations while paying particular attention to urban and traffic system development stages.

Chapter 2

Theory of Traffic Policy Development in Relation to Energy Efficiency

The traffic jam is a typical modern social problem caused by the motorisation that accompanies urban development. While the demand for logistics increases with economic development as the economic model shifts from a focus on self-employment, through small to medium-sized companies, to major companies, the demand for transport for each individual increases as occupational and living areas become more separated by distance. Furthermore, in addition to population growth through the process of urban development, the use of automobiles also increases due to a rise in income levels, bringing about a cumulative increase in the total use of automobiles. However, not only is transport infrastructure typically increased only after a problem occurs, transport policy involves massive costs and time, making it difficult to address changing conditions quickly enough. Thus, the traffic congestion that occurs as a result of this time lag is an unavoidable social problem for growing cities.

While economic losses are listed as one of the primary adverse effects of traffic congestion, another negative effect is a drop in energy efficiency due to the worsening of fuel efficiency. As energy consumption for transport comprises roughly one-third of all energy consumption in the world,[1] transport-related energy loss is a vexing problem from the standpoint of both energy security and environmental conservation. Currently, the effective use of public transport is essential for supplying the demand for transport economically and efficiently from an energy standpoint. It is desirable to develop cities with a high rate of public transport use.[2]

Today, a growing number of cities are experiencing significant economic and population growth, particularly in Asia, and extreme traffic congestion is occurring in some of the region's major cities. Similar situations are expected to develop in other regions including Africa, Asia, and South America. With the demand for energy increasing every year and expected to continue to rise, improving energy efficiency is an urgent issue. Accordingly, the transport problem is one in which energy specialists must involve themselves proactively. Previously, energy research focused on impact analysis of constituent factors, such as improving fuel efficiency, and research on the transport problem as a whole has been inadequate. This report considers the measures that should be adopted in response to the transport problems faced by modern cities from the standpoints of both the transport economy and the energy economy by considering the basic mechanisms of those measures with a focus on qualitative analysis of urban transport.

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[1] IEEJ, EDMC Handbook of Japan's & World Energy & Economic Statistics 2014.

[2] Here, public transport refers to mass transport systems in cities such as trains, subways, buses, and light rail transit.

1. Transport Demand and Traffic Congestion

This report begins by examining the characteristics of transport demand and analysing how congestion occurs. These considerations enable the correct application of congestion-solving measures.

Transport refers to services related to the moving of goods and people. Currently, the supplying of transport services requires four elements: routes, transport equipment, power, and terminals. Notable characteristics of these services include the high demand, immediacy,[3] locality,[4] the effect of intangible factors, and wide fluctuations in demand. These elements and characteristics have a major effect on the transport problem.

From a transport economy standpoint, traffic congestion represents a state in which transport demand for roads exceeds the transport supply. When congestion begins to occur in a city, it is usually caused by an increase in transport demand; a significant and sudden fluctuation in supply is unlikely. The nature of demand is related to the degree of need for transport. Generally, demand is comprised of intrinsic demand and derivative demand. Intrinsic demand refers to normal demand, representing the aim of a desire to 'do something'; while intrinsic demand refers to travelling for its own sake, such as going on a drive or taking a cruise for fun. Although intrinsic demand exists for transport, it is a somewhat unique form. Most transport demand in modern society consists of derivative demands that stem from the various intrinsic demands (the demand to move), including commuting to work or school and travelling to locations for shopping or leisure. Thus, any increase in demand is generally caused by changes in areas other than transport itself, such as in changes in economic demand and changes in social structure. Furthermore, the total sum of these activities is strongly correlated with population, and population increase is one of the primary factors behind the growth in transport demand.

In addition, the rate of automobile usage, which is directly connected to traffic congestion, is strongly correlated with income level (Figure 2.1). Generally, a rise in income leads to a rise in automobile usage, leading to traffic congestion. At the same time, public transport is often used more by lower socioeconomic groups, and its income elasticity is negative. When public transport takes on a negative image as the mode of transport of the poor, automobile usage trends become even more significant.

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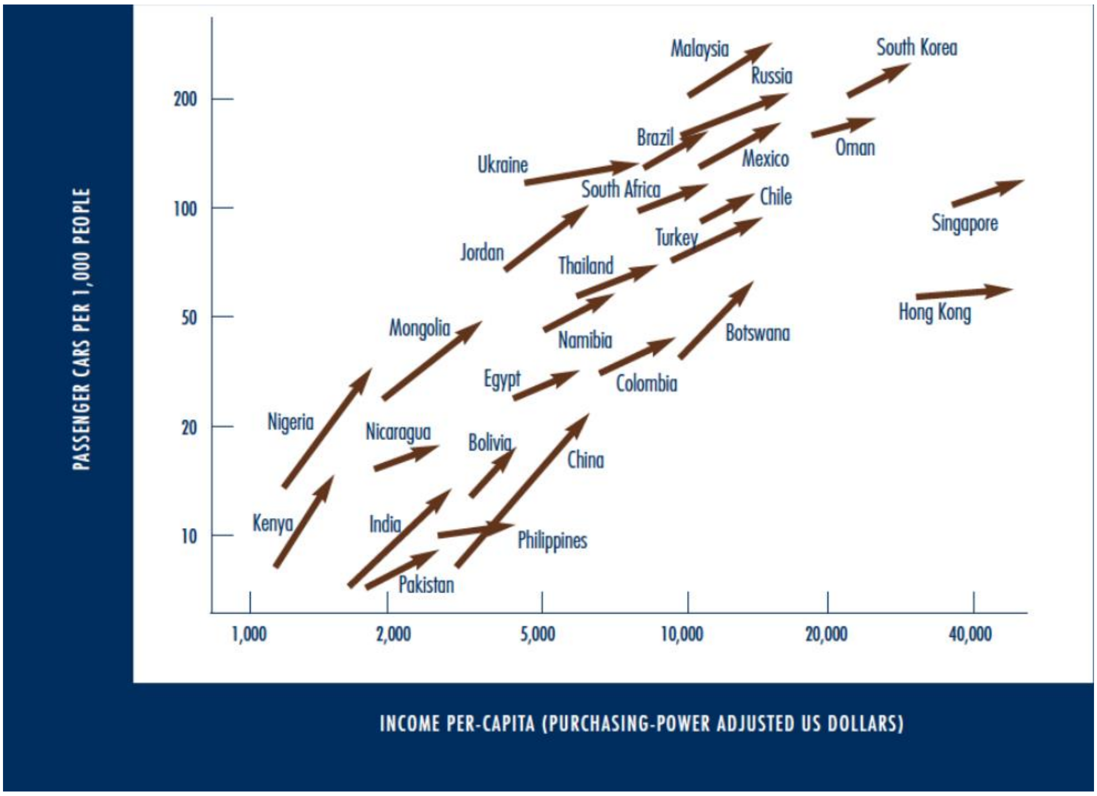
[3] Immediacy means that consumption occurs concurrently with the supply of services. Supply speed and timing become important as a result.

[4] Locality means that the locations of the supply of services are fixed. As a result, supply problems occur in areas where demand is inadequate. Further, regulations and control are important because monopoly conditions can occur easily due to the lack of competition between goods across multiple regions.

Figure 2.1: Income Level and Number of Cars Owned



Source: ACCESS Magazine. http://www.accessmagazine.org/articles/fall-2010/megacities-megatraffic/

Two frequently mentioned negative effects of traffic congestion are economic losses and energy losses. For instance, in Japan, the Ministry of Land, Infrastructure, Transport and Tourism estimates that the opportunity costs of traffic congestion represents an economic loss of ¥12 trillion per year. Meanwhile, in the United States, the average time spent in traffic congestion per person is twice that of Japan, representing a major economic loss. Furthermore, other negative effects of traffic congestion, including external effects, are often mentioned, such as a rise in traffic accidents and a deteriorating roadside environment. From an energy standpoint, driving at a slow speed during traffic congestion greatly worsens the fuel efficiency of automobiles. For instance, compared to driving at 25 kilometres per hour (km/h), driving at only 10 km/h drops halves fuel efficiency. The automotive industry goes to great lengths to improve fuel efficiency by several percentage points each year, but solving traffic congestion would have a much greater effect on improving fuel efficiency in a shorter period of time than technological improvements by automobile manufacturers.

In the coming years, road transport demand is expected to increase in regions where a rise in population and economic development is predicted. Traffic congestion is already becoming a significant social issue in developing countries in Asia. The same phenomenon is expected to occur in other regions, such as Africa and Central and South America, coinciding with economic development. Appropriate measures will be required to avert economic and energy losses in these regions.

2. Measures for Traffic Congestion

Logic dictates that the two available responses to the high transport demand on roads are to either limit transport demand or increase supply. In this case, when speaking in terms of the micro economics, the discussion will then generally proceed to a consideration of the relationship between price and demand. However, the characteristics of transport mean that this is not necessarily the case. Because traffic demand primarily consists of derivative demand, while the necessity is high, it is typically not elastic in terms of price, and thus adjusting demand via price cannot be expected to be effective.[5] Further, in the case of road-based transport, there are hurdles involved in collecting fees. Moreover, controlling demand through extreme price measures would be undesirable from a social welfare standpoint because it would interfere with the intrinsic demand of basic social activities such as employment in the case of commuting to workplaces, and academic learning in the case of commuting to schools. Accordingly, simply using price adjustment to change the traffic demand for roads is unrealistic.

2.1 Supply-side measures

Methods for improving supply capability can be categorised into (i) methods that directly increase supply, such as increasing road capacity or rationalizing road structure; and (ii) methods that improve the supply efficiency of the road environment, such as adopting cutting-edge technology, such as electronic toll collection systems,[6] or policing street-side parking (which impedes supply). Automobiles did not exist in pre-modern cities, and most roads, with the exception of city highways, were paved and designed primarily for pedestrian traffic and small vehicles such as carriages or rickshaws. Further, as populations were generally much smaller than today, handling modern motorisation is generally difficult in terms of volume and road quality without engaging in road improvements. Thus, improving roads to make them compatible with automobiles, including widening them to accommodate cars, paving them, and adding drainage, is a minimum condition that must be met in modern cities.

However, the improvements in the road environment lead to a further increase in road transport demand. If automobile use is to rise continuously with the rise in incomes, then not only will road capacity need to be increased accordingly, but this increased capacity will bring about a further rise in demand.[7] In cases where public transport services exist, the expansion of road capacity has the effect of lowering the overall appeal of public transport. Not only will this worsen traffic congestion, but it can pose a threat to the continued existence of the public transport system. Further, the land required for parking spaces that serve as terminals for automobiles becomes massive in scale, causing an extreme rise in the costs of preparing road

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[5] Pricing theory is discussed in section 5.

[6] The electronic toll collection system is a method used to collect expressway fees electronically using machines.

[7] This is known as the Pigou–Knight–Downs paradox or the Downs–Thomson paradox. It states that the equilibrium speed of car traffic on a road network is determined by the average door-to-door speed of equivalent journeys taken by public transport.

infrastructure.[8] This then causes more demand for parking and brings about fuel waste and environmental problems, as well as externalities such as noise and vibration. Automobile-centric transport leads to the marginalisation of groups for whom such transport is difficult, such as the elderly, children, and the disabled. To tackle these issues, the demand for road transport needs to be reduced while improving the efficiency of transport to the extent possible without departing from the original purpose of meeting the intrinsic demand.

2.2 Demand-side measures

There are several approaches to controlling road transport demand. The first is to reduce the need for travel to meet the intrinsic demand. For example, those who need to travel to meetings could hold teleconferences and thus eliminate the requirement for travel. Another effective approach is to shorten the distance travelled. For example, situating occupational and residential areas in close proximity can greatly reduce the distance travelled. Further, unlike tangible or storable goods, transport is a characteristically immediate resource that cannot be stored, and therefore involves the so-called peak (demand) problem. However, by diversifying behavioural patterns, such as using flexible working hours or staggering days off, transport demand can be levelled out without adjusting the overall volume. This can have the effect of solving traffic congestion.

There are many other similar methods to limit demand without adjusting pricing, but the most effective method at present is likely to be a modal shift towards the use of public transport. The use of public transport is not only more efficient than automobiles in energy used per person, but it also tends to be more punctual and stable. It is therefore an excellent way of meeting transport demand. Further, introducing public transport as an alternative transport mode brings about price elasticity for road traffic demand. In other words, the increase in the number of options available causes transport demand, which normally does not react easily to pricing, to become more sensitive to pricing. This makes the various policies for mitigating traffic congestion more effective. For instance, it enables the mitigation of traffic congestion through lower congestion charges, with less loss of consumer surplus. Further, a degree of improvement in efficiency can also be expected through competition. Simply stated, the provision of alternative transport choices in response to intrinsic demand for road transport can be expected to bring about competition between transport modes and improved transport efficiency.

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[8] About 25 square meters of space per automobile is required. When applied to the population of the Hong Kong Transit Oriented Development, discussed in section 5, and assuming an average automobile ownership rate of one per person, it would be necessary, albeit highly unrealistic, to secure roughly 80 percent of available land for parking space. This reality likely influences the strong relationship between high city density and public transport use.

3. The Traffic Congestion Trap and the Optimal Timing of Measures

While the above section explains the mechanism by which traffic congestion occurs and the solutions that may be used, many cities throughout the world still suffer from severe congestion. The primary causes are a lack of the necessary capital or technology, and the problems of determining the optimal scope and timing of projects.

In this section, the discussion will begin with an overview of the traffic congestion trap and a discussion of the optimal timing of measures. The typical pattern is that as the use of automobiles increases with urban growth, attempts are made to expand road infrastructure, but this is not done fast enough for the supply to meet the demand. Subsequently, the adverse effects of congestion are acknowledged only as the congestion grows severe, after which various measures are taken, including modal shifts. An increase in automobile use is typically seen as symbolic of social development and prosperity, and is viewed positively until traffic congestion becomes severe. Thus, any increase typically does not lead to an attempt to limit it.[9] Accordingly, any measures taken typically only happen after the adverse effects of congestion on the economy and environment become a problem for society.

However, as effective measures for traffic congestion involve massive scale construction, such as road expansion or the preparation of public transport, these measures cause temporary impediments to the very transport they wish to address. Traffic congestion may even grow worse during the construction period due to the construction itself, and thus solutions for traffic congestion incur considerable costs and losses. Furthermore, once traffic congestion occurs, measures cannot be taken right away. For instance, preparing a subway line takes at least five years for the construction work alone, and can require at least 10 years for the entire project, including obtaining the requisite land and carrying out all necessary paperwork. Thus, the defining characteristic of the traffic congestion trap is that it can come about easily but is difficult to solve. However, it is easy to prevent such a problem from occurring by taking advance measures. At the very least this means that cities should prepare plans that can be implemented with lower budgets. This would allow the economic and energy losses caused by congestion to be minimised.

To implement advance measures appropriately, their nature must be properly understood. The first thing to understand is that advance measures are by no means free. Large-scale road expansion or the construction of public transport systems are easier to implement as advance measures because traffic congestion is not yet severe. Thus, the major merits of advance measures are the larger number of options and the fact that large-scale measures for traffic congestion that include urban planning are quite feasible. However, advance measures involve a certain level of difficulty even at the stage of selecting whether or not to carry out the measures. It can be difficult to obtain the approval of city residents for measures when congestion has not yet occurred. Without residents' approval, politicians become less motivated to carry out advance measures and are unable to avoid the traffic congestion trap.

[9] Singapore is a notable exception.

Furthermore, even in cases where city residents are rational enough to support advance measures, there are yet more difficulties involved in the timing and scale of construction projects such as the construction of a subway. Although advance measures are required to avoid the traffic congestion trap, this does not mean that measures should be carried out thoughtlessly as soon as possible, and it must be remembered that funds invested become sunk costs that make pulling out impossible. Thus, transport projects characteristically involve the optimal stopping problem[10] due to the need for irreversible decision making. When there is a simple increase in transport demand, it is theoretically possible to calculate the timing for implementation using the first year rate-of-return method.[11] While the question of how to position the figures used as criteria is a difficult problem in the real world,[12] it is possible to make an automatic decision that an investment should be made when the transport demand exceeds a certain volume. In the case of measures taken after the fact, it is desirable that projects are carried out as soon as possible, and thus decisions on timing are unnecessary as a rule.

There are many other instances that require high-level decision making for advance measures. A state in which traffic congestion is not occurring suggests that the city's intrinsic demand is not yet particularly great. For instance, in terms of transport demand caused by commuting, it would mean that the labour demand by companies was not yet high. In that case, the question of where future demand develops can be greatly affected by the transport network itself. This has a major effect on city design, and thus must be tied closely to urban planning. Furthermore, with regard to scale, there is a considerable risk of over-investing and being unable to realise a profit when the current level of transport demand is not yet causing congestion. Under the optimal stopping problem, the timing of an investment is calculated based on the assumption that the amount of investment has been determined, whereas in fact, the determination of the appropriate scale is itself a difficult problem. While the Henry George Theorem[13] might be applied here, some creativity would be required as there are difficulties involved in the applicable conditions. In the case of measures taken after the fact, the scope of investment can be determined because the intrinsic demand is already clearly defined, and it is simply a question of designing the network to efficiently meet that demand. This is because if a subway were constructed in a location that was unrelated to commuting destinations, then it would not fulfil its role and would not bring about a modal shift. In that respect, measures taken after the fact will depend heavily on the city's structure.

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[10] The optimal stopping problem is a mathematical approach for choosing a time to take a particular action in order to maximise an expected reward or minimise an expected cost.

[11] Masayuki Doi, *Transport Economics.* In other words, if the difference between the net present value of a project and the net present value of that project were it implemented one year later is calculated, it will be smallest when the ratio of net benefit in investment for the first year is equal to the discount rate, so the net present value can be maximised by initiating the project in the relevant year.

[12] However, the method cannot be easily applied in practice depending on the interest rate or project timing.

[13] The Henry George Theorem estimates the optimal size of a city by comparing aggregated benefit and loss attained by the accumulation of economic activity.

Thus, there are several drawbacks to advance, pre-emptive measures compared with reactive measures taken after the fact (Table 2.1). Whereas measures after the fact identify solutions based on current problems the city faces, advance measures must be based on an expectation of future problems, and involve the work of creatively transforming existing cities. Thus it is necessary to adequately consider not only the importance of this work of developing a foundation for the city's economic future, but also the difficulty of doing so due to the inherent unpredictability and risk.

Table 2.1: Characteristics of Advanced and After-the-Fact Measures

Reactive Measures	Pre-emptive Measures
・Easily gives rise to chronic supply shortages ・Construction to increase supply itself causes further congestion ・Dependent on existing city structure	・Timing of measures is difficult ・Obtaining approval of citizens is difficult ・Alters city structure

Source: Study team.

4. Public Transportation Design

Before considering the design of public transport, its purpose must first be clarified as a precondition. The purpose of public transport is generally to meet the derivative transport demand. Public transport design that aims to shift hobby drivers to use public transport or to maximise benefits for tourism or train aficionados will not be discussed here.[14] Rather, the aim will be to understand the derivative requirements. It has already been explained that an approach that considers price alone is inappropriate for understanding derivative demand requirements. This leaves the problem of what basis to use. The domain of transport economics uses the concept of generalised cost.[15] This concept views the elements of transport – time, frequency, regularity, reliability, accessibility, safety, and comfort – as costs and aims to minimise those costs. While there are many elements to generalised costs, users base their decisions on bounded rationality, so it is not necessarily a requirement to consider every element. Rather, costs that are easy to detect take on a relatively high importance. However, this report will discuss the validity of this method or the algorithms used. Rather, discussions will be based on the rule of minimizing the amount of time required to reach the destination,[16] and to do so as swiftly, safely, comfortably, and cheaply as possible.

[14] There are transport services that aim to meet the intrinsic demand of tourism (such as leisure boats or tour buses), and this report does not intend to deny the importance of off-peak high value-added transport.

[15] The generalized cost concept has been criticized for the difficulty of seeing the effects of individual elements, and the high risk of preferentially benefiting the wealthy due to an emphasis on time cost. While these weaknesses must be acknowledged, the concept is still unquestionably an effective tool for understanding the effects of costs other than price.

[16] Wardrop's First Principle.

4.1. Rapidity

The basic issues for rapid transit are equipment, the independence of routes, operational frequency, and access. The existence of transport equipment that can travel swiftly is essential for rapid transit. If the rule of taking the minimum time is set as a precondition, then if there is a method of public transport for which the time required is greater than when using roads, then traffic congestion will continue to increase until the time required by road matches that required via public transport. In other words, as a rule, such a public transport system should not be designed. Street buses that lack their own independent roads are at a disadvantage, and it is thus difficult to mitigate traffic congestion using such buses. However, this is not to deny buses as having value as public transport. The quality and performance of buses have improved in recent times, and they are capable of travelling safely at higher speeds. For example, whereas it takes 60 minutes to travel from Tokyo Station to Narita International Airport via the Narita Express train service,[17] so-called limousine buses take about 80 minutes, which maintains a level of competitiveness. As the operating interval of these buses is roughly 20 minutes shorter than the train, the average amount of time spent in transit becomes the same from the standpoint of travellers without reservations. However, as the limousine buses travel on the general expressways, they can experience significant delays when traffic congestion occurs. The chance of delays for trains is relatively low. The routes used by trains are independent of general traffic, which leads to rapid and reliable travel. While the perception of buses is that they are generally affected by road conditions, some cities have achieved rapid and reliable service for their BRT by establishing dedicated lanes for buses (Figure 2.2).

[17] Narita Express is a limited express train service operated in Japan since 1991 by JR East, serving Narita International Airport from various Tokyo area stations.

Figure 2.2: Bogota Bus Rapid Transit System

Source: Institute for Transport & Development Policy. http://www.itdp-china.org/

From the standpoint of transport economics, public transport should be designed to achieve travel times that are equivalent to road travel under optimal congestion conditions. The optimal congestion conditions are found at the intersection between demand and marginal social cost, but when demand for roads is such that congestion occurs unless measures are taken, then some congestion will still occur under optimal congestion conditions. However, it may be difficult to calculate the marginal social cost accurately, and it is desirable to eliminate congestion completely from the standpoint of energy efficiency. Thus, it is recommended that public transport is sufficiently competitive with the travel time required via automobile when there is no congestion, for the sake of convenience. Travel time should include waiting time and access time, and it is thus necessary as a rule for the design to maintain an advantage in terms of travel time compared to private automobiles in non-congested conditions.

Private automobiles are available for travel at any time provided one is prepared to drive, whereas public transport does not operate according to individual whim, and thus a certain amount of waiting time is unavoidable. As this waiting time comprises part of travel time, it is important to limit waiting time in order to achieve rapid transit. Operational frequency is therefore an important factor. For example, on the Moscow subway a timetable is unnecessary because 40 trains operate per hour during peak times (the subways operate according to a 90-second frequency comprised of 20 seconds stopped at platforms and 70 seconds of arrivals and departures). As a result, waiting times are extremely short. However, even for public transport systems that operate at a lower frequency, it is possible to minimise passenger waiting time through the use of timetables and punctuality. For example, in Japan, while train frequency is lower than on the Moscow subway, punctuality is extremely high, and thus timetables are very reliable. This allows passengers to arrive at stations immediately before the departure, allowing them to minimise their waiting time. Online services display current operating conditions, providing greater precision, and allowing passengers to further reduce waiting times. However, this still does not remove the disadvantage that availability is not 24/7 and is restricted to the operation schedule, which reduces the appeal of public transport as a transit method.

Similarly, reducing access time to terminals is another essential factor for rapid transit. In the case of advance measures, housing can be developed within walking distance of terminals to increase the convenience of using public transport for residents. Further, it is also important to consider that building taller structures can increase the population living within the access range of the terminals. When considering access by methods other than walking, such as bicycle, motorbike, or automobile, it becomes necessary to secure parking space near the terminal. Access from the parking area to the terminal itself is also important. Furthermore, additional public transport is sometimes provided to provide access to terminals for those who do not own or cannot ride automobiles or motorbikes, such as children or the elderly. These systems are called feeder lines. When designing feeder lines, it is necessary to apply the same principles used in other public transit such as travel time, waiting time, access, and transfer time. These feeder lines must provide an advantage in travel time over bicycles and motorbikes, but realistically, it is difficult to make such lines advantageous compared to motorbikes, even while bicycles might be feasible. In that case, the use of the feeder lines will drop, causing a drop in feeder line operational frequency, and a further widening in the competitive advantage of motorbikes. Thus, measures such as giving an access advantage over motorbike parking areas must be considered.

Transfer time is another major factor affecting travel time. To minimise transfer time from one route to another, it is necessary to design for cross-platform transfers or multi-level platforms (Figure 2.3). Furthermore, congestion within terminals themselves can be a major problem. Congestion at ticket counters can be addressed by the use of integrated circuit (IC) (or 'smart') cards and monthly passes, while congestion at ticket gates can be addressed through gate distribution and the adoption of automated gates. Congestion when boarding and exiting trains can be mitigated by installing wider doors, promoting queuing, and widening platform walking paths and stairways. As each of these elements affects l time, careful design is required during the planning stage.

Figure 2.3: Cross-Platform Transfer between Bullet Trains

Source: Country Renovation by Railways. http://rtpl.ce.osaka-sandai.ac.jp/ByRail/?p=829

4.2. Safety and comfort

The choice of transit method does not depend on travel time alone. Safety and comfort are also important elements. Very few would question the value of safety. When comparing the number of accident-caused deaths per passenger-kilometre, commuter trains, railways, and aeroplanes are incomparably safer than automobiles. This is because for those methods of travel, it is much less likely to collide with other vehicles or objects. The key to accident prevention for these travel methods are appropriate equipment maintenance and operation. Safety can is a greater an issue for buses. While the number of accidents per kilometre travelled is less for buses than for automobiles in Japan, this is dependent on regional characteristics, and the likelihood of bus accidents is not universally low. Although buses are more commonly the perpetrators of accidents and damage to the bus is often limited, it cannot be said that buses are safe as a result. Most bus accidents are caused by human error, and thus driver training is the most important factor in their prevention. Training is important not only for avoiding collisions on roads, but it is also essential for the prevention of accidents on board. As the weight of buses is relatively low, they have a high rate of acceleration and deceleration compared to trains, and the passengers are not necessarily seated, as they would be in automobiles. For that reason, accidents within the buses when starting and stopping are very common. The establishment of independent lanes for buses, as was done with BRT, is effective in preventing accidents through steadier driving.

The element of comfort is not easy to process in terms of transport economics. Not only is the definition of comfort subjective, but it is also difficult to measure.[18] However, as comfort is an extremely important element in the choice of travel method used, it would be inappropriate to use the excuse that it is not objective avoid discussing it. This report will therefore mainly consider common perceptions while examining some specific examples. Firstly, there are likely countless ways to interpret the reasoning as to why comfort is important. As comfort itself is an added value, it is possible to say that its improvement represents a discount if the price remains unchanged, and use of the relevant mode of transport will increase. However, from the standpoint of transport, the explanation that comfort represented a practical reduction in travel time could also be suggested. Borrowing the concept of perceived time, time spent in fun and comfort is perceived to go by faster, whereas in the opposite case, time is perceived to go by slower. Air conditioning can serve as a typical example. In regions where the external temperature is hot or cold to an extreme, public transport can make use of air conditioning to create a comfortable environment. Other possible measures that may lead to comfort during transit include the reduction of motion vibration or the provision of useful information within the vehicle.

However, the difficulty in creating comfort is that it is not always clear what comfort is. For example, there is no universally comfortable temperature setting for air conditioning. While some might find the setting too cold, others might find it too hot. In that case, setting the temperature in the middle range would lead to a maximisation of comfort.[19] Another proviso when considering methods to improve comfort is should be something that cannot be provided separately and its provision does not cause a loss of overall benefit. For example, on-board television is a service that could be replaced by individual smartphones, and should be approached with caution when considering the possible drop in benefit due to noise. The practice in Japan of using video without sound is one reasonable option. One interesting trial will be the installation of aroma diffusers in ticket gates for trains by the Tokyu Corporation. Fragrance is a factor that cannot be provided separately for each individual, yet individual preference for fragrance is even more varied than for temperature. Thus, the trial will limit the number of gates that give out the fragrance, allowing passengers to choose. Using measures such as this in areas where smells tend to reduce comfort, such as in toilets, may be another way to improve overall comfort.

These examples suggest that, to improve comfort, it may be more reliable to focus first on reduce externalities related to the use of public transport, rather than working on areas in which personal preference may vary – a policy of removing discomfort rather than aspiring to comfort. For instance, an air purifier might be installed to improve air quality. Because nobody would object to cleaner air, it is highly likely that this would improve comfort. Ensuring the cleanliness of vehicle interiors would be a similar measure. For measures such as air

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[18] There are several methods available, and the method used typically depends on the subject being covered. Typical methods include contingent valuation, conjoint analysis, the replacement method, and the basic unit method.

[19] Using the median voter theorem. However, in the case of temperature, the deviation is likely to be small, thus realistically speaking, using the average may be enough.

purification, where it is difficult to become aware of air quality, proactively informing passengers of the efforts to clean the air may result in an improvement in comfort.

One reason why it is important to be sensitive to passenger comfort on public transport is because automobiles are a mode of transport with a generally high level of comfort. Automobile interiors are completely private spaces that users can customise to their liking, setting the temperature, applying fragrances, or playing music according to their preferences. Not only is the level of comfort generally high, but the mental concentration on driving has the psychological effect of accelerating the perceived passage of time. Even when traffic congestion and other driving troubles lengthen travel time psychologically, the level of comfort is still higher than what can be achieved by public transport. When designing public transport, adequate awareness of the competitive advantage of the automobile is needed to ensure that the environment is not uncomfortable.

However, public transport also has the intrinsic advantage that most of the cost related to travel time can be reduced. For most people, the greatest cost incurred by travel is not the travel fare itself, but the opportunity cost from the standpoint of economics. Were an individual not required to travel, they might have spent that time relaxing and reading a newspaper, or studying for a test at their own pace. However, it is still possible to make effective use of time spent travelling on public transport. Except when congestion is extremely bad, it should be possible to read a newspaper or listen to music on one's cell phone inside the vehicle. Screening educational videos inside school buses might even be the equivalent of time spent in the classroom. The provision of imaginative services on long-distance rail that is unaffected by congestion can lead not only to profits for the line operator, but a reduction in opportunity cost for the passengers.

Other issues faced by public transport include maintaining security in the enclosed spaces of the vehicles. Another would be that when vehicles contain objects within them unrelated to the purpose of transit, they have the effect of reducing the supply of transport in practice. This represents an increase in opportunity cost for the transport operator, and thus it would be possible to charge not only for distance but also for time. When installing shopping malls or restaurants in train stations, it may be necessary to develop a system for exempting users from time charges while they use those facilities. Yet another issue is disadvantage regarding transportability when comparing public transport with automobiles, though this may not be a major issue in terms of the focus on urban transport in this report. Automobiles are more convenient for those with a great deal of luggage to carry. One possible measure to address this would be tie-ins with freight delivery services, but there is currently no way to provide a service that is equivalent to the convenience of the car for public transport, and thus such improvements should be expected primarily in long-distance transport.

5. Operational Policy for Public Transportation

This section will discuss management issues related to realising the design of public transport operating in a manner that maximises its social value. The latest trends in management will be considered with a focus on finance and pricing.

While there are cases where public transport is operated by private companies, in many cases it is operated publicly. Public use is described as the shared use of a resource by an indeterminate number of customers. This definition could be used to describe supermarkets or restaurants. However, there are almost no examples of publicly operated supermarkets or restaurants.[20] Public management of public transport is common because it is difficult to manage and the management risks for private companies are great. The three major reasons for this are the massive initial investment required, the size of the external economy, and the fee-reduction-based industry structure. The issues facing management in light of these reasons will be discussed.

When starting to manage a public transport investment, managers are faced with the complex problem of initial investment. The entry into the market by newly emerging companies that lack capital resources is almost impossible because of the extremely high initial investment amount and the high risk of losing money. The logical optimum timing for project implementation has already been explained. However, the problem is that as the logical optimum timing is calculated according to the profit of the transport project, it may not necessarily result in a timing that could considered an advance measure. For instance, applying the method of the first year rate of return on a massive scale public transport investment project, such as a subway line, shows that a considerable number of potential users is a requirement. If no other public transport exists until then, it would not be surprising if congestion was already severe. In that case, the project would be indistinguishable from a project implemented after the fact. In other words, it is not always possible to avoid the traffic congestion trap using optimal timing theory alone. At the same time, it should not be considered appropriate to force public transport operators to accept losses. This problem can be addressed through internalisation of the external economy or balancing pricing policy with competition.

5.1. Internalisation of the external economy

Firstly, the benefits accumulated through the preparation of public transport can also be collected from areas other than the income obtained by the operator. Generally, the improvement of public transport leads to an improvement in benefit for the surrounding area. For instance, this would mean more sales in a commercial area, or an increase in the number of potential residents for a residential area. As a result, these benefits would ultimately be

[20] Public management of these establishments may be seen when there are state level restrictions or when there is inadequate private management capacity, such as in state-run restaurants in North Korea, or the former Bando (Peninsular) hotel in Seoul, as well as in cases where high-level management is required in addition to the pursuit of profit, such as in the Paradors of Spain.

reflected in land value.[21] In this case, the final recipients of these benefits are the managers of the commercial areas or the residents, and ultimately the land owners, and as long as they have not invested in public transport, they enjoy the free ride of a windfall profit in terms of the external economy precipitated by the public transport project. This means that the public transport operators themselves cannot enjoy the profits of their own investment. This can lead to underinvestment in the infrastructure required by society, which necessitates that land owners should return these unearned profits gained from the external economy. If this were to happen, then the profits gained from public transport projects would better fit the investments made, and might enable the timing of projects to be advanced.

There are examples where the government has mediated to prepare policies to redistribute the investment benefits of the external economy of surrounding areas back to the public transport operator. For instance, in the United States, higher sales taxes are collected in areas that benefit from the provision of public transport facilities,[22] while special taxes can also be collected from areas designated as special tax zones.[23] In Northern Virginia, the establishment of a special tax zone is expected to provide funding of up to $1 billion for the development of the Silver Line.[24] In France, property and residency taxes are collected from companies and residents located along train routes, and companies that meet certain criteria are taxed based on total salaries paid as a transport contribution.[25] The tax rate is 2.6 percent in such regions as Île-de-France, where Paris is located, and the department of Hauts-de-Seine. When the social benefits are redistributed to public transport operators as taxes in this manner by the government, the benefits of investment other than actual fare income is returned, improving the profitability of the investment for the operators. In Japan, funds were collected for the construction of the Midosuji Line from land owners and shops located within a radius of 700 meters from stations. As the Osaka Municipal Electric Bureau, owner of the Midosuji Line Project, was a publicly owned utility, this project follows the same pattern. While collection efficiency is improved by utilizing government tax policy, it is difficult to calculate the actual benefit; hence it is not easy to decide where to draw the borders of the collection zones and how to set the level of collection. Residents would generally claim that they were already paying for the costs of the benefits they receive in the form of train fares, or that the benefits of public transport development are already reflected in property taxes with the rise of land value. Furthermore, there are likely to be cases where redistribution does not benefit public transport. For example, Japan has an urban planning tax that taxes land and buildings located within the municipal area based on fixed asset tax valuation. However, this is not done only

[21] This is known as Capitalization Theory. In fact, criteria include the ease of transit, city conditions (small/open), and perfect competition in property trading. If the effects of issues such as noise or environmental contamination are greater than the benefits, then land value will drop.

[22] This special tax zone is known as a special assessment district, and can be applied to infrastructure other than transport.

[23] This is similar to consumption tax and value-added tax, but it is not applied to purchases made for resale. As the tax rate differs per state, purchases made outside the state are sometimes applied with a use tax representing the difference.

[24] This line will extend the existing metro to reach the Dulles International Airport and Ashburn.

[25] This is called versement transport and was first adopted in Paris in 1973.

for the purpose of developing transport, these taxes are commonly applied to general finances, and the relationship between burden and benefit is unclear. Obviously, such cases would not promote investment in public transport. However, from the standpoint of promoting a modal shift, it would be reasonable to collect funds from surrounding residents who choose to use automobiles rather than the subway. Thus, based on these issues, a system of funding must be designed that matches the goal.

A variant on this theme is the internalisation of social benefits brought about by transport investment by the investing organisation itself. This would entail the investors undertaking development along train routes at the same time as investing in the transport infrastructure in order to include the profits of these developments in the total business profits. This approach is also desirable from an economic standpoint. When the operator carries out transport development and development along routes at the same time, if fares are set too high, then residents will leave, sales will drop for commercial establishments, and land value will drop to a new equilibrium point as a result. The drop in the number of residents will lead to a reduced transport demand. Therefore, fare prices are set via the marginal cost pricing principle, which maximises the social benefit. Furthermore, in theory, investment in transport continues until the optimal point where the social benefit of the investment becomes equal with the marginal cost of the investment.[26]

Examples of this approach include the development along routes by the Tokyo Corporation and the Hankyu Railway Company in Japan.[27] Land surrounding train stations is bought up as new routes are established, and profits are obtained by selling the land once the route is completed or by using it for the construction of housing or commercial areas. Only 40 percent of the Tokyu Corporation's operating profits[28] are obtained from transport operations – a smaller return than is obtained from real estate. Similarly, the operating profits for the Hankyu Hanshin Group are also slightly over 40 percent, and the amount generated from real estate is similar. This does not mean that these ratios are economically justified. In both cases, the operators are also involved in businesses such as supermarkets, hotels, and advertising, while Hankyu also operates the Hanshin Tigers baseball team and the Takarazuka theatre group. Each is engaged in a wide range of businesses, including some for which the possible synergy between the location and the transport business is unclear (Figure 2.4). This might be assumed to be for the purposes of optimisation of the business portfolio. In any case, regardless of whether the behaviour of each operator is intentional, it would be inappropriate from the standpoint of transport economics to simply interpret route-side development on the part of rail operators as only the creation of demand. Rather, the development is required to recover the losses incurred by investing in infrastructure.

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[26] A criterion for this is the developer theorem that the areas along routes are developed exclusively, while a state of competition exists with another operator in other areas.

[27] This company began as the Denentoshi Company, whose purpose was the development of housing. They entered the rail business to serve residents, which is the opposite approach. In contrast, Hankyu grew out of the Minoo Arima Electric Railway and entered into route-side development as part of their transport business.

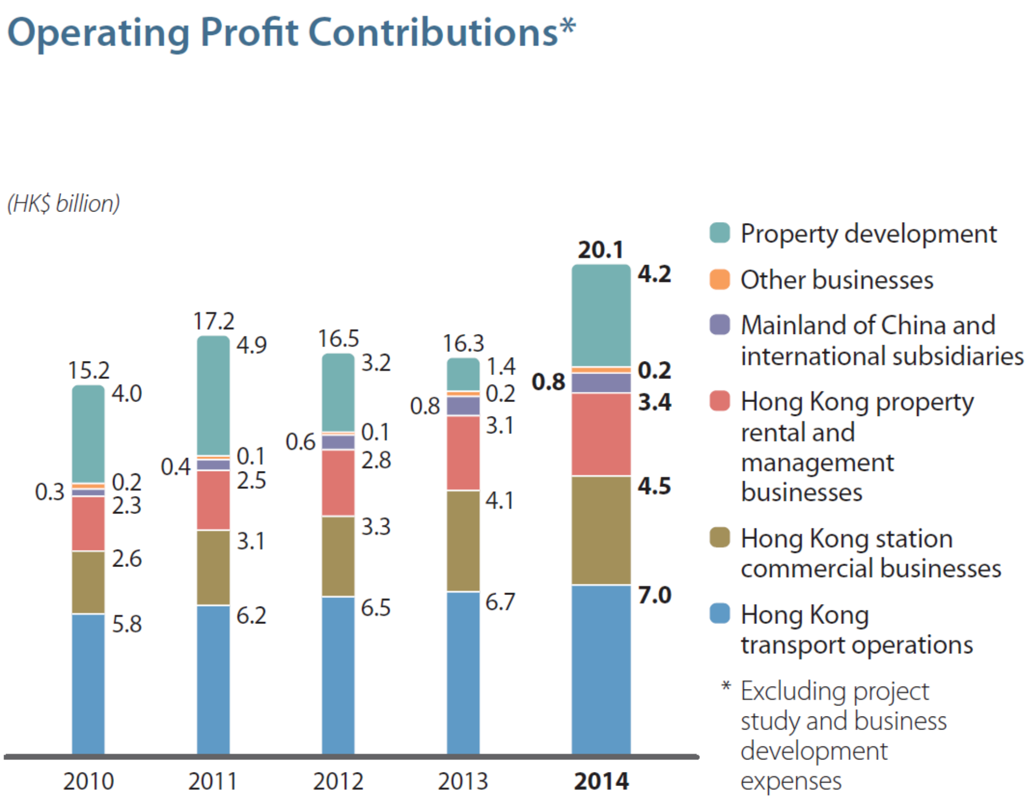
[28] Operating profit is defined under Japanese accounting standards.

Figure 2.4: The Business Model of the Tokyu Corporation

Source: Tokyu Corporation website.
http://www.tokyu.co.jp/global/english/company/about.html

Similarly, when developing subway routes in Hong Kong, the MTR selects developers for the land above through competitive bidding and achieves returns from the external economy they create by either receiving a portion of the income according to contracts from the facilities developed there or by taking partial ownership of the assets. Profits from purely rail operations represent less than 40 percent of the operating profits[29] for the Hong Kong railway that operates the MTR (Figure 2.5). The scale of income from related businesses precipitated by transport investment is considerable. The unique aspect of the Hong Kong example is that the rail-side development is being carried out using developer capital. In the case of both Tokyu and Hankyu, there is the risk of incurring losses for both the rail and real estate businesses were the development to fail. Thus the approach of managing risk by having the development carried out by developers while securing a certain level of the social benefit brought about by transport development can serve as a reference for transport operators for which finance is a weakness. The example of the Hong Kong MRT is likely to contribute to the optimisation of transport investment by providing returns to operators on the benefits brought about by the public transport.

Figure 2.5: Breakdown of Operating Profits for the Hong Kong MTR



Source: MTR website. http://www.mtr.com.hk/en/corporate/investor/financialinfo.html#01

[29] Here the operating profit is defined as operating profit before depreciation, amortization, and variable annual payment.

However, this method of internalizing the external economy on the part of the business operator requires that development along the routes where transport is being improved has not progressed extensively. The approach is normally not feasible for transport investments taken after the fact, where development has already taken place, because of the cost of negotiating separately with each business and land owner in the relevant area, and thus it would be recommended for the government to take an intermediary role. Further, even for areas where route-side development has been limited, it would be expected that a large amount of speculative investment would flow into local real estate the moment it was learned that a decision had been made to invest in transport for the area. To avoid this situation arising, land use should be legally designated beforehand and sufficient land should be secured for infrastructure such as roads, parks, schools, and libraries. As can be seen, it is necessary to tie transport investment closely to urban planning.

5.2. Balancing pricing policy with competition

The second effective measure for improving the operation of public transport is the design of pricing policy. As is clear from the discussion so far, investment in transport is highly risky. Not only is the amount of initial investment high, the external economy is also large, and if care is not taken, the benefits will be lost to third parties. Further, the market for public transport can easily fail, and this factor becomes extremely important if the aim is to implement advance measures. Initial investment for public transport is large, yet demand will not necessarily be adequate. In that case, it is highly probable that the equilibrium point between supply and demand will be found in the range in which long-run average costs decline. If, accordingly, pricing is carried out according to the marginal cost pricing principle, then the price will drop below the average cost and the business will lose money. Furthermore, the cost reduction structure will mean that the operator will aim to expand the scale of the business. If multiple operators do this in a competitive market, then only one winning company will remain, along with the massive-scale assets of the losing companies.[30] A single company will then dominate all profits, pricing will be based on profit maximisation, and the maximisation of the social surplus will not be achieved.[31] Hence, public transport businesses not only are there the risks associated with the size of the investment and the difficulty of recovering the benefits, but they also face the risk that the large investment can cause a decline into a state of competition while money is being lost. It goes without saying that one cannot expect there to be investment in such a business in the face of such risks. To minimize this risk, pricing need to be managed in such a way that destructive competition and structural losses are avoided. Accordingly, pricing design must take these factors into account. Prices should be set with the primary aim that the transport operator should not lose money so that its competitiveness

[30] This type of competition is called destructive competition, and ultimately leads to a state of natural monopoly.

[31] There are arguments that suggest this would be optimized through the threat of new market entry, or that the second-best fare would be formed according to contestability theory, it is rare for either of those conditions to work due to the existence of technical advantage or sunk costs of investment.

can be increased and social benefit can be maximised. As these policies arise from market failure, it would generally require government intermediation and regulation.[32]

a. Full-cost pricing

One method to avoid losses is to design pricing based on full-cost pricing that aims to secure the appropriate level of costs and profits. There are two approaches to full-cost pricing: the cost-stacking approach, whereby fares are set by adding an appropriate profit to the operating costs; and the rate-based approach, also known as rate-of-return regulation,[33] in which fares are set by adding asset values multiplied by the fair rate of return to operating costs. Under the rate-based approach, the fair return must match the opportunity costs, so the profits must not be seen as excess profits but as the normal profit that should be obtained from the invested capital. However, these pricing approaches have problems. First, they do not encourage companies to improve profits by reducing operating costs, therefore they can serve as a disincentive for improvements in company management. Second, they aim for equilibrium in the balance of payments, and do not consider the optimal allocation of resources. Thus, the social optimum is lost in pursuit of equilibrium in the balance of payments. Third, there is a limit to the extent to which losses can be avoided. For instance, in the case of electricity and water, price elasticity of demand is extremely low as both services are required for daily life and there is no substitution. However, public transport can be replaced by the use of automobiles and bicycles. Thus while price elasticity is generally not very high, an extremely high price may lower transport demand. If the price is too high, then a vicious circle can be created where the number of users falls, the smaller number of passengers causes a reduction in train frequency, and convenience is further reduced. The rate-based approach in particular can become an incentive for inefficient investment,[34] and can cause a drop in social benefit due to price distortion. Therefore, pricing policy must be designed with an adequate understanding of these challenges.

b. The franchise method

Several approaches promote management efforts on the part of companies. For instance, rail privatisation was carried out in the United Kingdom in 1994.[35] The operation of infrastructure, such as stations and tracks, was consigned to Railtrack; while the operation of the trains was

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[32] Intermediation could also be handled by a cartel if the government chooses not to be involved. For instance, in the transport domain, the number of flights and pricing adjustment is carried out by an airline consortium. The shipping alliance was also once considered outside the scope of anti-monopoly law, but the alliance ceased to exist in 2008, and today there is intense competition in pursuit of scale with the creation of groups through mergers and maritime shipping alliances.

[33] As the name implies, there is freedom in pricing decisions because the policy aims for controlling the upper limit of fares.

[34] This incentive towards over-investment is called the Averch–Johnson effect.

[35] There are several formats for this method of dividing the rail companies into infrastructure and operations, which are called a 'two-tiered system'.

divided into zones for consignment to train operating companies using a franchise format via bidding.[36] Problems typically highlighted for this approach include bid-rigging between bidding companies, the high hurdles to participation, and the disposal of the assets of existing companies; but the worst outcome in the case of the United Kingdom was inadequate maintenance caused by the introduction of the principle of competition. For example, a defect in the automatic warning system caused the Southall rail crash in 1997 to be a severe accident. In another example, the Ladbroke Grove rail crash (Figure 2.6) of 1999 could have been avoided if automatic train protection had been in use, despite the conductor's lack of sufficient operation skill. It was not used because of the cost of the system.[37] The problem of lack of maintenance became obvious with the Hatfield rail crash in 2000. In that accident, the intercity train derailed when metal fatigue caused the rails to break, killing four people.

It would be overzealous to blame this series of accidents on the adoption of franchising. However, it does highlight important issues regarding the competition principle.

First, the reader might recall the film *Class Action*. The subject of the film was the fuel tank controversy surrounding the Ford Pinto. The salient point was that Ford had used cost–benefit analysis to determine that the payment of lawsuits was more economical than measures to fix the defect. However, it is difficult to make valid calculations for cost–benefit analysis that consider all of the numerous indirect effects,[38] and even the calculation of direct benefits is subject to the assumptions and limitations of the person doing the calculation. Calculations of the ripple effect from the social impact caused by anger, suffering, and fear over accidents in the real world often lack validity. Analyses made before the accident merely calculate how much compensation to pay the victims. However, Railtrack lost the public trust, and the comprehensive repairs it subsequently undertook bankrupted the company. As shown through the discussions so far, the transport industry is typically a cost-reduction industry that can easily lose money. It is thus necessary to fully understand that if the competition principle is adopted carelessly under these conditions, then necessary costs will be reduced by sacrificing safety and comfort, and there is a risk of destructive competition occurring if losses continue. Thus competition policy must be combined with related regulations to ensure that safety is not sacrificed in the name of competition.

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[36] The franchise format was established by the Railways Act, 1993. Bidding was originally managed by the Office of Passenger Rail Franchising. The function was taken over by the Strategic Rail Authority according to the Transport Act, 2000, and has been carried out by the Secretary of State for Transport since 2006. The franchise period is generally seven years.

[37] Vigorous debate on transport took place in the UK in 2000 as a result of those accidents, but the ironic outcome was that support grew for not using automatic train protection because of its high cost.

[38] Usually, only direct effects are considered. For instance, cost–benefit analysis for road projects in Japan cover the direct time-saving benefit, drive cost saving benefit, and accident-reduction benefit.

Figure 2.6: Ladbroke Grove Rail Crash

Source: Swindon Advertiser.
http://www.swindonadvertiser.co.uk/news/11514267.Paddington_rail_tragedy_remembered_15_years_on/

Second, although revenue for non-competitive part of separated business, in this case ownership of rails and cars, is typically thought to be stable, the adoption of the principle of competition to other part of separated business, in this case operation of train system, raises the risk of bad debt. Furthermore, there is the possibility of bankruptcy if revenue and costs become unbalanced as in the case of Railtrack. The separation of operations (competitive division) and infrastructure (non-competitive division) precludes optimisation that combines both; therefore, a system to secure revenue centred on full-cost pricing is necessary, as well as provision of both regulations and higher-level administrative authority to the non-competitive division from the competing division.

c. The yardstick method

Another typical approach to pricing policy is the yardstick method. In this method, the standard cost is calculated by comparing the operating costs of multiple companies managed under the full-cost pricing, and fares are then set based on the standard cost. Under this pricing scheme, more-competitive companies are able to turn a profit and less-competitive ones are weeded out. Problems with the yardstick method include bid-rigging between companies, information asymmetry, and the validity of comparing costs across different regions. For instance, the standard price for route buses in Japan is calculated using the average price of operators that meet certain criteria after dividing the country into 21 blocks. Currently, about 70 percent of bus companies are operating at a loss. The ratio of personnel costs is high for the bus industry, and companies have reduced salaries to deal with it. However, there are downsides to this approach. If competition continues to intensify, the industry will face not only the elimination of uneconomic routes, but personnel reduction following salary reduction, which would increase the workload of each driver. It remains to be seen whether high morale and safety can be maintained, and talented personnel recruited as salaries are reduced.

d. The price cap method

The price cap method is another typical pricing scheme. It calls on operators to carry out management improvements compared to the standard fare level for a specific year and a productivity improvement rate established by the governing body. While this method has the major benefit that calculation of the cap price is easy, the difficulties include the additional information cost incurred in determining the productivity improvement rate, and the impossibility of eliminating arbitrariness from the validity of that rate. There is also the fundamental problem of what to do with use of the cap price results in losses. The price cap, franchise, and yardstick methods all suffer from the problem that safety and comfort are lost due to the worsening employment conditions and cost reductions incurred when the competition principle is introduced into an industry that can easily lose money.

e. Congestion pricing

The important points regarding congestion pricing and peak load pricing schemes will also be explained briefly. Congestion pricing is an approach typically applied to roads for automobiles, rather than to trains, which deals with the question of whether to collect transit fees during congestion. Provided the appropriate rate of congestion is exceeded, collecting congestion fees is seen as desirable, because those who continue to use the roads despite the fee are those who are receiving a great benefit from the roads.[39] Drivers who cease using roads because of the congestion fee are those for whom the benefit is small, or for whom the alternate cost of public transport is less. Thus, from the standpoint of resource allocation, it is desirable to shift such drivers to alternative resources to mitigate the congestion. However, the problems of collection costs and fairness remain.

Peak load pricing is another option for public transport organisations that is similar to congestion pricing. This policy is effective in controlling demand at peak times by setting fares high for those times without affecting demand for off-peak times, which are relatively inexpensive. This policy has been adopted for numerous subway operators such as those in London, Sydney, and Washington DC. One reason that pricing policy is necessary is that the marginal cost pricing principle would not work. To maximise social surplus under those

[39] As with Dupuit’s bridge, efficacy is considered high for people with a high willingness to pay.

conditions,[40] fares should be set high inversely to the price elasticity.[41] Normally, peak times for public transport are during peak times for commuting to work and school, and thus are highly necessary. Thus, although peak load pricing may be a rational pricing scheme from the standpoint of social surplus, it has a major problem from the standpoint of fairness. Ramsey pricing is a form of discriminatory pricing. Given that there is little room to adjust work and school commuting demand through pricing, other policy support would be required through cooperation with society, such as flexible working hours and telecommuting, and the placement of schools and factories outside of central business districts.

In summary, we have observed pricing policy that promotes competition while avoiding destructive competition in light of the tendency of public transport toward natural monopoly as a cost reduction industry. Some policies are expected to cause the weeding out of less-competitive companies. From the standpoint of private companies, weeding out through competition may seem valid. However, there are markets where competition between private companies does not work. If public investment can meet the transit demand for the relevant area in the most economical and environmentally friendly manner under current operation, then one should not depart from the standpoint of avoiding losses and keeping the company alive, because weeding out that company would reduce social benefit. For example, if a certain route was eliminated with the adoption of the yard stick method, and there were no more efficient transit methods available for that route, the residents in that area would have no choice but to purchase automobiles. Such a contingency is not what the pricing policies aim for, and could simply be described as destructive competition backed up by that policy.

5.3. The use of private companies

To this point, we have primarily discussed the difficulty of managing public transport in comparison to normal businesses in terms of finance and pricing policy. To conclude, we will discuss the various approaches to leveraging the capabilities of private companies to provide public transport. When the characteristics of public transport are considered, it is a natural outcome for there to be many public enterprises. However, there is a limit to the funds, personnel, and skills available to government. Thus it is pertinent to ask how to leverage the vitality of the private sector. This type of initiative is being leveraged for improving infrastructure in numerous forms through public–private partnership (PPP). This can take the form of a private finance initiative approach where the private sector contributes funds,[42] or some other format, and the type of contribution can be divided into involvement in design, construction, operation, and/or maintenance. Further, there are numerous patterns regarding the degree of freedom in operations and planning in terms of whether the project is run by

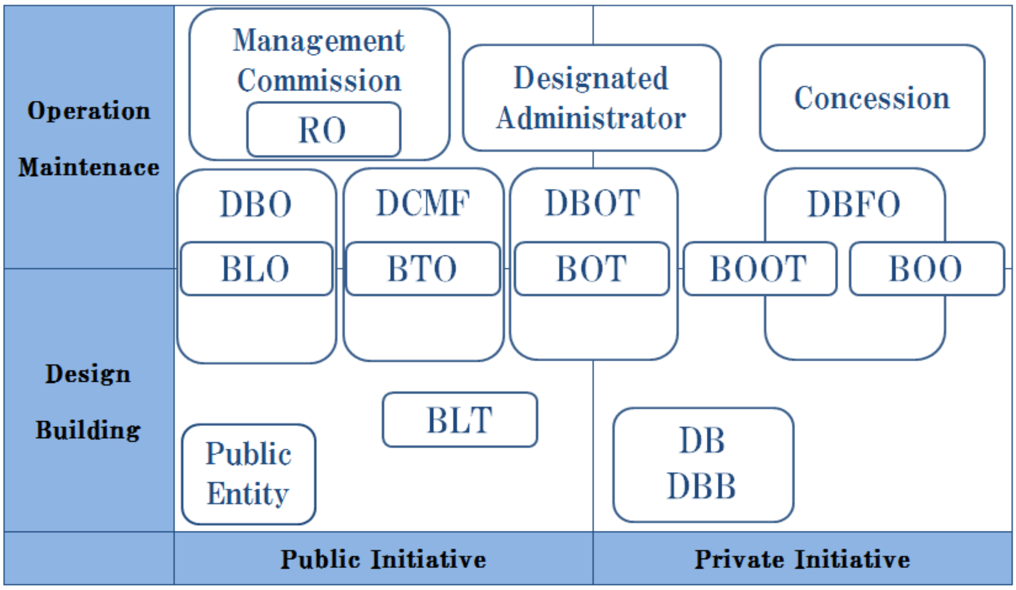
[40] This is called second-best pricing.

[41] The rate of deviation from the marginal cost of fares is set inversely to the price elasticity. This type of approach is called the Ramsey rule, and the approach to pricing based on it is called Ramsey Pricing.

[42] Private finance initiative describes the use of private sector assets in public investments. In addition to the use of private capital, this approach aims to leverage private human resources and management capabilities and to improve the efficiency and quality of public services.

the government or the private sector (Figure 2.7). For instance, the franchise method used in the United Kingdom could be considered a type of concession.

Figure 2.7: Public–Private Partnership Categories



BLO = build–lease–operate, BLT = build–lease–transfer, BOO = build–own–operate, BOOT = build–own–operate–transfer
BOT = build–operate–transfer, DB = design–build, DBB = design–bid–build, DBFO = design–build–finance–operate
BDO = build–develop–operate, DBOT = design–build–operate–transfer, DCMF = design–construct–manage–finance
RO = rehabilitate–operate.
Note: The positioning in the diagram does not necessarily reflect actual conditions. For example, in the BLO approach, construction is carried out by the private sector and government-owned assets are leased for operation by the private sector; so the approach can thus be said to be similar to the concession approach, but it could also be considered similar to a management commission if the government has strong command constraints on management. Thus the actual situation depends largely on the contract. Further, as the relative position depends on what is considered leadership, readers are recommended to consult a specialist publication for details.
Source: Study team.

Common examples of PPP include airports, expressways, and waterworks infrastructure. For transport infrastructure, the mass rapid transit (MRT) project in Kaohsiung, Taiwan, is known as a build–operate–transfer project. The private sector Kaohsiung MRT was created primarily by Taiwan's largest steel manufacturer, China Steel, which is headquartered in Kaohsiung. The two lines currently operating are the Red Line and Orange Line, while a light rail loop line is under construction. Revenue from fares is only about 20 percent of transport income, and the operation is still running at a loss as the income does not yet cover asset depreciation. The number of daily passengers – currently about 150,000 people – is increasing, it is still inadequate. About 60 percent of transport in the city is by scooter, while automobiles comprise roughly 20 percent. As the population density of the urban area is high enough, it is likely that policy support for a modal shift will be required. As an incentive is needed to design a better public transport system and increase the number of passengers, a policy of raising or lowering a subsidy depending on passenger volume, such as the 'shadow toll'[43] used for roads, could be considered as a form of support. Other examples of development patterns for public transport through PPP include the Manila Metro Rail Transit System, the Bangkok Skytrain, the Kuala Lumpur Monorail, and the Adelaide–Darwin railway.

Incentives for companies to enter public enterprise primarily include extending the main business into other regions, a synergistic effect for the main business, and the nurturing of new business. These incentives match the growth strategy of Ansoff's matrix[44], and are rational choices on the part of the companies. Thus, if an attempt is to be made to attract companies to participate in PPP projects, it is important to consider such company motives and proactively approach companies with which synergies can be cultivated, rather than to publicly solicit for participants. Furthermore, although compatible legal policy is not a requirement for carrying out PPP projects, the preparation and execution of laws has been inadequate in some cases. This presents an uncertainty that can reduce private companies' incentive for investment. Further, the most important point for investors is business profitability. Hasty projects that cause bankruptcy for the private company that operates them would be pointless. Thus it is most important to keep in mind the topics discussed so far including internalisation of the external economy, such as through real estate development or government mediation, and pricing policy, in order to make the transport project sustainable.

5.4. Examples of new initiatives

In addition to rational design based primarily on the principle of time minimisation and an emphasis on comfort and safety as discussed so far, public transport initiatives should also be carried out based on the return on investment and pricing policy described in this section. After considering the above, this report will discuss other management-related issues with a focus on new initiatives seen in actual transport projects.

a. Automation

Automation can be seen in numerous areas of modern society, and its merits for public transport are great. Areas where automation can be applied include ticket-selling machines, ticket gates, and train operation. The merit of automation for public transport is typically seen as simply the reduction of personnel costs. Other merits of automation include reducing operation mistakes, increasing speed, and preventing fraud and corruption. However, the

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[43] A shadow toll is a contractual payment made by a government per driver using a road to a private company that operates a road built or maintained using private finance initiative funding.

[44] Ansoff's matrix is a framework for segmenting business strategy, which consists of the market development, diversification, market penetration, and product development.

installation of expensive advanced equipment incurs great cost and maintenance costs are considerable, and in regions where labour costs are low, or where operations are efficient, it may not directly contribute to reducing costs. For instance, in Europe and North America, where a proof-of-payment method is used, the adoption of automated ticket gates would cause a reduction in revenues except in major cities with a large transport demand, or where the ratio of non-paying passengers is extremely high.[45] It also brings risks, including the risk of all functions ceasing to operate when there is a bug in the software or when the central system goes down, and the risk of exposure to cyber terrorism. For ticket sales, where machines are most commonly adopted, full automation is currently difficult for transfers and seat reservations, or complex criteria for receipts.

b. Increased convenience

Improving convenience is an important factor in promoting the use of public transport. Widely implemented measures that improve convenience include the optimisation of ticket purchasing using IC cards, the provision of internet access within trains and train stations, and advance reservations of tickets via the internet. The use of IC cards, for example, is important not only from the user's standpoint, but from the company's standpoint as well, not only in terms of customer retention, but to conserve paper used in tickets and for the optimisation of ticket selling machines and automated ticket gates. IC cards are often used as a payment method for shopping as well, and recently, it has become possible to use them for security or transit data capture for companies, and for making use of reservation services via smartphone apps. If the IC cards contain information that identifies the user, it will be possible to leverage them for services that require registration of personal information, such as hotel check-in or bicycle or video rental. When the scope is extended to increasing convenience in areas other than transport, the creation of a synergistic effect on convenience may be a form of added value.

c. Station area development

It may be a good choice of public transport company to contribute directly and indirectly to the promotion of development in the areas surrounding train stations. For example, Harvard University, Massachusetts Institute of Technology, and Nagoya University are almost collocated with subway stations. In these cases, the existence of university promotes ridership on the subway. Similarly, simultaneous development of commercial building, shopping malls, and/or residential houses together with train station will increase the utilization and thus profitability of public transport.

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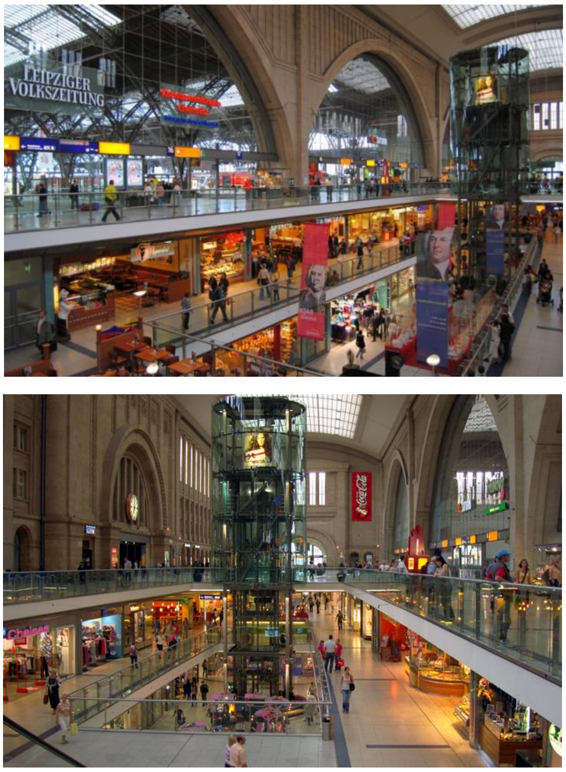
[45] Non-paying passengers are believed to be only about 6 percent because ticket inspectors are deployed on trains and large penalties are incurred for non-payment, and in many cases, the adoption of automated ticket gates is put off for financial reasons in cities with low numbers of public transport users.

The convenience of the station itself is also an important theme. Although a station is merely a public transport terminal, the fact that many people use the station means that there is considerable potential for business. Improving the convenience of busy train stations can contribute to a major improvement in convenience for the area, and to greater use of public transport. While such facilities typically focus on shops that cater to basic transport user demands, such as kiosks and restaurants serving light meals, the separation between these facilities and those found in towns is narrowing with the addition of convenience stores, proper restaurants, bookstores, and apparel shops, well as banks, drug stores, and other services. From the standpoint of commerce, stations and the surrounding towns should not be clearly separated, and it is increasingly necessary to pursues efforts for improving mutual appeal through adding values. This should include pedestrian pathways and improvements to the station atmosphere carried out with an understanding that the seamless integration of station and town strengthens the town's appeal (Figure 2.8).

d. Handling tourist demand

Finally, although the major issue for public transport is meeting the normal transport demand of work and school commuting, it is also important to provide convenient transit for tourists. To date, this has primarily consisted of basic measures such as the deployment of station staff able to speak foreign languages, the installation of signs in foreign languages, and station announcements made in foreign languages. However, the use of smartphone apps should be developed more for this purpose. Convenience for tourists would increase considerably if, in addition to providing information on routes, transfers, timetables, and surrounding tourism resources in their native language, tickets could be purchased with an IC card using smartphone apps. The provision of transit with the same level of convenience as in the tourists' home country is growing ever more feasible through the use of information and communication technology. Furthermore, measures to highlight the appeals of the communities surrounding train stations have hardly been implemented, with the exception of certain tourist destinations. If the train station jointly advertises with the surrounding communities, it may greatly benefit both the public transport company and the local community.

Figure 2.8: The Promenade at Leipzig Hauptbahnhof (main station)



Source: Leipzig main station promenade.
http://www.leipzig.travel/jp/___1393.html,
http://www5d.biglobe.ne.jp/~ma-sat/travel/2009/2009de-18.html

This concludes the brief discussion of the issues of value addition in the management of transport systems. The important common viewpoint for each is the passenger-oriented approach. Transport is a mid- to long-term service that cannot be separated from its region, and thus a management strategy that pursues short-term profits is inappropriate. In the long term, the creation of communities and public transport systems that are highly convenient for passengers can improve the appeal of a city, and by doing so, attract new residents and lead to an increase in passengers, and thus can ultimately improve the profitability of the public transport business.

6. Government Transportation Policy

So far, this report has discussed the mechanisms and measures for traffic congestion and the design and operation of public transport systems. There is great potential for finding effective improvement measures based on an examination of the actual urban transport conditions and a consideration of the issues discussed so far. However, this will not solve all of the issues faced. Even if the same transport system is developed and managed by the same operator, the outcome would be entirely different depending on the city. This report will next consider what the root cause of this gap might be from the standpoint of city structure and government policy.

6.1. Public transport and city structure

First, city structure has the greatest direct effect on transport. The city's population that provides the context for the number of passengers, and the location of industry in the city determines the directions for transit. The question is: what type of city structure is desirable from the standpoint of transport? Given that the most basic type of transit in modern cities is transit from the home to the workplace, it can be assumed that distance travelled is proportional to the distances between homes and workplaces. In that case, if the minimisation of energy consumption for transit, and the idea that transit itself should be minimised as a derivative demand, then it would be desirable for the distances from homes to workplaces to be short. Furthermore, when city structure is considered from the standpoint of the transport company, a high passenger rate would be desirable. A high passenger rate would require there to be many passengers living within access of the train station. Conversely, a situation with urban sprawl, where regions with a low potential passenger rate are spread about in a disorderly manner, would be undesirable for the transport operator. When both factors – the shorter distance from homes to workplaces and the higher passenger rate – are considered, high-density city structures are desirable both in terms of energy efficiency and for the profitability of the transport operator.

Furthermore, then when the city is made more compact, it will be possible to prepare more terminals for public transport in a smaller area because there are more potential passengers. This would create a positive feedback loop as between the transport system and the city itself as the increased convenience of the area attracts more accelerates immigration into the area. Conversely, in cities with a declining population, a vicious circle would be established in the opposite direction as the public transport system would typically attempt to maintain profitability by reducing the frequency of trains or buses, even though this reduces convenience. One reasonable approach to escaping from the vicious circle would be to reduce services on the less dense fringe of the city while maintaining the level of services in the city centre to promote making the city more compact and maintaining highly efficient management. This would incur the hurdle of relocation for residents living in fringe areas. However, if the problem is ignored, then the public transport system would ultimately be forced to choose between bankruptcy and lowering convenience, either of which would lower the vitality of the city and ultimately cause its decline through competition with other cities.

Thus, to generalize, a certain degree of density is required for public transport to be successful, and the size of the city must be limited relative to population to maintain the necessary population density for public transport. While there is no established theory on what constitutes a desirable density, Hong Kong, with its planned residential area of about 30,000 people/km, provides an example of the density of a transit-oriented development (Figure 2.9).[46] Density is increased through the use of high-rise apartment buildings, and a

[46] Transit-oriented development is urban development that is based on public transport and aims to achieve a society that is not dependent on cars. It promotes the use of public transport by building more commercial facilities intensively around the public transport stations in the centre of cities and developing residential areas systematically in the vicinity of public transport stations in the suburbs.

comfortable environment is created by securing parks and open spaces. The balance with commercial areas is considered to achieve the ideal urban development for pedestrians. Transport with an appropriate capacity for the population must also be prepared. The city structure and transport are influence and regulate each other.

Figure 2.9: Images of Transport-Oriented Development in Hong Kong

Source: ATKINS.

When such ideas are raised, there are typically many arguments against them. The arguments often tend to cherry pick data, including convenient data on agricultural towns, special industrial cities, or examples that forget about subsidies from the central government. But it must be remembered that, as a rule, this is a discussion of cities that are focused on the tertiary industries, and not a discussion of places such as agricultural towns or Silicon Valley.

6.2. Concentrating city density

High-density city structures do not occur naturally. Rather, if the city is left alone, it will tend to spread out. As increasing a city's density requires technology and considerable cost, it can be difficult to achieve in low-income areas. Thus government policy is extremely important for the development of highly dense cities. Policy can promote the advanced utilisation of cities

See_http://www.epd.gov.hk/eia/chi/register/profile/latest/cdir137.htm. It can be seen that there are many similar projects being carried out by the MTR.

by improving related laws. For example, Japan's City Planning Act specifies the purpose, height, building-to-land ratio, and floor area ratio for buildings under a consistent plan for the overall city. Further, tax advantages for high-rise apartments can serve as an incentive that guides city structure. The choice between renting and purchasing homes can also influence city structure, as home purchases can lead to rigidity in transit patterns, which can further increase the risk of obsolescence for those areas. Extreme disproportion of resident's age distribution can lead to sudden changes in transport demand. When the rate of purchased homes is high, there is a greater risk of immobilisation of residential areas if the home resale market is not vigorous.[47] Regular planned redevelopment is therefore necessary. The obsolescence of areas will affect transport demand, which can also threaten to the region's transport infrastructure. To avoid such obstacles, urban planning must balance planning at the city level with that at the local level.

Furthermore, some countries exempt commuting costs in salaries from taxation,[48] but as land prices generally fall with distance from the central business district, they serve as an incentive for living in the suburbs. On the other hand, a tax-free allowance on the housing tax that is proportional to land price might contribute to increased city density. There are easy arguments offered against these points.[49] However, such policies do not determine overall structure, and this rule is not limited to city policy. Rather, efforts to bring about major change in structure through individual policies are a type of imposition, and while they might be successful in achieving one goal, they run a high risk of causing distortion elsewhere. The structure of the city is the outcome of the collection of related policies. While the effect of each policy on the overall situation might be minor, city policy and transport policy must be assembled with care and balanced from multiple standpoints through the skilful combination of force, encouragement, and guidance.

6.3. Public infrastructure efficiency

From the standpoint of regulated pricing, there are many cases where full cost pricing has been applied to infrastructure, and while overall cost is typically considered, there are many cases where cost per area has not been reflected correctly. This is a vexing problem that needs to be improved. In some cases, the profits from highly dense areas are used to cross-subsidize less-dense area. This relates to the earlier discussion on the closure of loss-making routes. While it is true that such discussions are affected by questions of efficiency and fairness, when management is facing a moral hazard through full cost pricing, irrational fairness is often seen.

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[47] The optimal residential area generally changes according to life stage, including the elements of location, function, and spaciousness. For instance, living environments appropriate for child raising and those appropriate for retirement are likely different. However, immobilized residences can serve as an impediment to these changes in life stage.

[48] Examples include Belgium, the Netherlands, and Japan, although there are criteria such as distance and price.

[49]See, for example, http://blog.japantimes.co.jp/yen-for-living/how-employer-transport-allowances-helped-
create-commuter-hell/

For example, 58 stations operated by JR Hokkaido serve only one or no passengers per day, representing 15 percent of the total, while 30 percent of stations serve 10 or fewer passengers.[50] Police stations, roads, and waterworks face the same problem. While this type of situation would clearly be renounced from the standpoint of economics, it should also be questioned from a viewpoint of social fairness to determine whether it represents true fairness or simply an end to thinking in the shadow of full-cost pricing.

Further, such situations are also extremely inefficient from the standpoint of the energy efficiency. From the standpoint of city structure, it would mean that those living in the city centre must not only pay high land prices, but they also bear the burden of costs for people living in the suburbs through public utility fees, and this is yet another factor that would promote the suburbanisation of cities.

This situation is sometimes justified from the standpoint of redistributing income or correcting income disparity because those with higher income have a higher capacity to bear the burden. But this discussion totally misses the point because it stands on an incorrect precondition that richer people live in urban areas and poorer people live in rural locales. The point here is that the pricing policy for infrastructure incentivises suburban living by offering the benefits of a lower than cost infrastructure price together with lower land prices, which lead to inefficient energy use.

However, considerable cost and energy is required to roll back a state of suburbanisation that has already progressed.[51] Increasing the density of cities that have been suburbanised is a task that must be carried out carefully over time. Furthermore, as the discussion so far assumes the formation of commercial districts that concentrate capital in urban centres, and centralised infrastructure policy, any significant advance in information and communication technology or distributed infrastructure would require a review of the discussion. However, as long as systems such as roads and power grid carry the role of connecting people, the principle that higher density leads to greater efficiency is unlikely to change in the foreseeable future.[52] Nevertheless, given that future technological developments could render cities obsolete, planners may need to move beyond maximizing concentration effects, and focus instead on making infrastructure more efficient or building meeting places that enable high added value.

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[50] http://headlines.yahoo.co.jp/hl?a=20160210-00010003-norimono-bus_all

[51] When new investment in urban areas is required through the abandonment of suburban assets with high asset value, problems include investment efficiency or energy wasted for construction. However, these do not apply for moving due to ageing homes or when there is excess housing.

[52] However, the appearance of technologies that are not dependent on fixed infrastructure, and technologies that make distance meaningless, such as wireless or remote technologies or the ability to warp location, would completely overturn these conditions.

6.4. Elements for transport policy

This report will now discuss policy that has a direct effect on transport rather than on cities. Before discussing tools for transport policy, we will review several rules that should be considered preconditions.

First, when transport policy is considered for the purpose of energy optimisation, the key question is how to trigger a modal shift from private cars to public transport successfully. The existence of public transport as an alternative to private cars is therefore a precondition. In areas where no public transport system exists, it is impossible to push forward a modal shift except in very small cities, highly dense cities, or cities with unique shapes.[53]

Second, transport demand is essentially an unnecessary demand, and the real goal is optimization. When attempting to increase transport mobility, for example, to mitigate traffic congestion, the problem will not be solved simply by expanding the roads.

Third, while it is typical to focus entirely on the outcome of policy, transport policy often incurs a massive financial burden, and thus it is important to secure financial resources.

Fourth, the side effects of policy must also be carefully considered to ensure compatibility with other policies. A balanced bundle of policies can serve as a powerful weapon, but how they are combined and how they are used is extremely important. As is clear from the discussion so far, there would be nothing wrong with including city policy within the collection of transport policies.

Finally, it is always necessary to consider uncertainty. While policies can possess a degree of logic and universality, they cannot be replicated like scientific experiments. The outcome of policy is greatly affected by the executor, recipient, external environment, related policies, and timing. Considering these uncertainties, the policy should maintain adequate flexibility and elasticity to allow adjustment according to the conditions.

a. Controlling demand through taxation

To control demand and road mobility, a combination of policies is needed to reduce congestion. Taxation of automobiles is one such policy that is used in many countries. Taxation is the natural thing to do in view of the transport infrastructure costs of the shared assets of roads and signals, and the externalities created by driving.[54] Furthermore, unlike regulations, taxation can serve as a financial resource for other policies. If taxation policy is used effectively, it should be possible to achieve both control of transport demand and financial stability. Taxation is generally categorised into taxation on fuel and on acquisition and ownership.

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[53] If the city population is 500,000 people or less, then increasing density in an area of approximately 10km^2 can be successful in creating a modal shift toward bicycles and walking. The same would also be possible in theory for cities with multiple hubs.

[54] However, it is difficult to quantify externalities, so the recommended approach would be one similar to the environmental tax suggested by Baumol Oates.

Further, it can include licensing fees and road usage fees in terms of collection method. The following points provide an overview of these taxes.

First, any taxation will lower demand for automobiles, although it may appear to have no effect. Second, different automobile taxes work at different speeds. Acquisition tax that has the greatest immediacy. However, it cannot reduce the number of automobiles already in use. A fuel tax would have an effect on automobiles already in use, but the short-term effect would be low,[55] and thus a mid to long term viewpoint would be required. This shows that although taxation is an effective method, is difficult to solve existing congestion in a short time through taxation alone. However, if public transport offers a very good alternative, the adoption of a fuel tax can make great progress towards a modal shift. Taxation examples include the certificate of entitlement, used in Singapore as an acquisition tax, and the aggressive implementation of gasoline taxes in Norway and Turkey.

Third, the purpose of tax collection does not need to be limited to road-related improvement costs. Rather, the funds should be applied to improving the appeal of public transport or to increasing the density of the city. it also does not need to be limited to automobile-related taxes. The special assessment tax in the United States and versement transport in France are taxes on residents of areas that reap the benefits of public transport that are used to fund improvements in transport infrastructure.

Finally, there is the issue of taxation timing. Taxes implemented only once not only have no effect in controlling subsequent use, but they also risk becoming an incentive for use. For example, a high automobile tax could lead to a mentality of using the automobile more frequently to justify the greater cost incurred.[56] Thus, taxation is an effective method that should be included in policy early on and strengthened continuously to promote a modal shift. This includes taxes on fuel, automobile renewal, licence renewal, parking, and transit.

b. Transport regulation

Regulation involves the application of certain limits to the freedom of transport to make it more efficient. This is mainly done through licensing and prohibition, and the establishment of conditions and standards. The taxation, licensing programs, and pricing policy described so far can also be considered a form of regulation. The following is an overview of the main points of regulation.

First, the relationships between regulatory goals and methods should be clarified. For instance, if a certain road were closed to solve traffic congestion, while the congestion on the road itself would clearly be solved in a sense, congestion in the overall area may worsen. Thus such a

[55] It is generally considered that the fuel has a mid- to long-term price elasticity rather than a short-term one. This trend is consistent with the prospect theory and ratchet effect described on the following page.

[56] This is a form of prospect theory. While not necessarily consistent with typical economic concepts, such as lifecycle costs or sunk costs, further theoretical research would be desirable because it is highly persuasive.

regulation would be appropriate if the goal was to solve congestion on that road alone, but it might be incorrect if there were other goals.

Second, and related to the first point, such that regulations often create negative effects because they interfere with freedom. When the goal of the regulation is for some social benefit other than the economic benefit, the regulation is typically not positive in economic terms. For example, environmental regulations that limit the use of inexpensive but fuel-inefficient automobiles might contribute to the improvement of the environment, but they may also have a negative economic effect by reducing the purchase or use of automobiles. There are already examples of transport regulations where the establishment of a gasoline tax led to an increase in gasoline smuggling, and the introduction of a high-occupancy vehicle lane led to the start of ride-sharing businesses.[57] There are also many cases where prohibition causes a rise in price, creating financial resources for organised crime via black markets. Some cities in China are limiting the purchase of automobiles.[58] When used effectively, such regulations are powerful, but they can also cause negative effects, and thus unnecessary prohibitions and regulations should be aggressively avoided.

Third, there can be problems with the execution of regulations. For example, when something is prohibited, then the act of prohibition only takes on meaning when people become aware and behave accordingly. Therefore, people need to be made aware of the prohibition, and those who violate it must be met with penalties and enforcement. Without education and enforcement, regulations become a mere facade. Where regulations function properly without such measures, the regulations themselves may be unnecessary. Spreading awareness and carrying out enforcement both incur costs, and although the application of fines can be an effective way of recouping those costs, the income may not necessarily exceed the costs. The effectiveness and side effects of regulations vary according to their severity, ranging from loose regulation to total prohibition, and each type should be used accordingly.

c. Subsidies

Subsidies are another important tool. The continued operation of public transport in unprofitable areas is due largely to government subsidies. However, regular expenditure in the form of public transport subsidies is not cost effective because they reduce the incentive for the transport company to improve. It is also difficult to stop the subsidies in a reasonable manner. Effective subsidies are those that stimulate a change in the structure of transport, for examples, by promoting an increase in urban density, or improving or expanding walking and bicycle paths. Subsidies for developments that increase the convenience of areas surrounding stations would also be effective. Simply extending routes in pursuit of increased convenience should be avoided, because that might risk increasing public transport management overhead

[57] High-occupancy vehicle lanes may be used when the number of occupants of a vehicle exceeds a specified amount.

[58] This is implemented in Beijing, Guangzhou, and Shanghai, and is expected to be expanded in the future. However, some experts claim that the limit on purchases has not led to a fundamental solution, and that the transport system should be improved.

and reducing transport efficiency. Whereas subsidies for route extension should be unnecessary if there is adequate demand. When demand is insufficient, a combination of route extension through subsidies and development of the surrounding area to increase transport demand should be considered. It is important to include clear goals and time limits to subsidies to avoid promoting dependency.

Toyama, Japan, is an example of a city where homes in the city centre are subsidised.[59] Indirect incentives for living in urban areas can also be created by adding criteria for eligible properties, such as in the residential subsidy for low income earners in Hong Kong.[60] Although subsidies may be necessary to maximise social welfare, they should be managed carefully because of their 'drug-like' effect. It is important to keep subsidies to the absolute minimum required when carrying out an operation to drastically alter the city, otherwise abuse of subsidies runs the risk of creating a zombie city that cannot survive without them. Furthermore, the overprovision of subsidies makes their management more complex, and risks fomenting political corruption. Subsidy policies should therefore be managed with wisdom and logic.

d. Policy combinations

It is important to carefully combine policies because each one has a limited effect but often has side effects. There is a risk that certain policy combinations will cancel each other out. Given that costs are incurred from creating policy through execution, such situations must be avoided and efforts should be made to create synergistic effects.

For examples of parking-related policies, regulations against street-side parking will not lead to the control of road congestion or transit volumes unless adequate parking lots and parking reservation programs are made available at the same time. This is a problem that occurs from the distortion caused by attempting to regulate a natural demand. For example, if an excessively high purchase tax is applied to automobiles to try and force drivers to stop using cars, then consumers will simply start using motorbikes. Similarly, a rise in the gasoline tax is likely to cause a shift to the use of hybrid or electric vehicles. However, the existence of an excellent public transport system that meets the latent travel needs of consumers might solve such problems. Finding the right combination of policies is extremely important.

Accordingly, we will next consider the basic principles of policy combination. For simplicity, the discussion will consider hypothetical policies rather than existing ones. First, let us assume that the goal of a certain policy is to cause positive effects or eliminate negative ones. Policies are implemented to achieve these goals, and their outcome can be divided into three general

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[59] Toyama's Unique Compact City Management Strategy. http://www.uncrd.or.jp/content/documents/7EST-Keynote2.pdf#search='compact+city+subsidy+high+building

[60] A Report on the State of Sustainable Building in Hong Kong (2008), http://www.iisbe.org/sbconferences/Hong%20Kong%20Report%20for%20SB08-%20final%20r1.pdf #search='compact+city+subsidy+high+building

categories. First, they may have no effect whatsoever. In this case, the policy is fundamentally mistaken, and should be rescinded from the standpoint of cost. However, policies that fit this category are rare unless they are irrational policies based on fallacy. Such policies may be designed to support fundamental structural change at the national level, such as the Great Leap Forward and the Aral Sea policy for cotton growing based.[61] There is also the risk that supply-side economics based on Say's Law can bring about policy mistakes.[62]

Policies that fall into the second category have an extremely minimal effect. For example, a low rate of gasoline tax would be unlikely to cause a major change in automobile usage. It would have a controlling effect on automobile use but the effect would be minimal. However, applying a high gasoline tax rate in response to this minimal effect would be inappropriate because of the side effect on the oil industry when consumers simply started using electrical or natural gas driven vehicles. Therefore, policy should be combined with other automobile taxes, such as transit fees or parking fees. The important thing is to effectively combine related policies with similar effects, rather than stick to a single policy and take it to extremes.

Some policies that are effective may also cause additional problems. For example, while it would be a mistake to consider a gasoline subsidy to be a policy of income subsidy only for the poor, it nevertheless does subsidise their income. This would clearly cause other problems such as triggering excess demand or subsidies for the rich. In that case, stopping the subsidy would have the merit of preventing the other problems from occurring. Such problems might also be solved through minor adjustments such as setting an upper limit to the amount of subsidy, though that would create problems of cost, or by establishing a system so that only the poor are subsidised. If, alternatively, such a policy were combined with others rather than changing the policy, this could be done by simply providing the poor with other subsidies, or imposing a levy on the rich, but that approach would have a high risk of simply making the policy more complex. If the additional problems caused are small or easily solved, executing the policy together with others that handle those issues would be recommended. (This is the principle of problem simplification.) For example, let us say that improved fuel economy was achieved at low cost as a result of policy that aimed to protect the environment. While this should cause a reduction in the consumption of gasoline, the total consumption could increase because of an improvement in fuel efficiency.[63] In that case, the cost of fuel would drop in practice, so the gasoline tax should be raised in steps according to price elasticity and the improvement rate in fuel economy. In other words, the paradox is created by the inappropriate combination of policies rather than by an improvement in fuel economy. While the additional

[61] The Great Leap Forward caused a major failure in agricultural crops due to the promotion of extreme close cropping and deep ploughing. Similarly, the policy of using water from rivers feeding the Aral Sea for cotton cultivation caused the sea to contract greatly, leading to severe smoke pollution which damaged the nearby environment and led to damage to the health of nearby residents.

[62] Say's law states that 'the value we can buy is equal to the value we can produce, the more men can produce, the more they will purchase', which means demand will increase according to increase of supply.

[63] This is known as the Jevons paradox. This phenomenon occurred with the early spread in coal use. Similar examples would include Pigou's paradox, the fact that there are few traffic accidents in snowbound regions, and that accidents increase with the use of seatbelts.

problem of an increase in fuel consumption was caused by the improvement of the poor fuel economy, this can be solved relatively easily through taxation or similar measures, and thus it should be handled through the combination of policies. As another example, if public transport was made free of charge in order to promote its use, then urban sprawl would increase because travel from remote areas via public transport would be free, and ultimately there would be a higher risk that the use of automobiles would instead increase. The issue could be mitigated by making public transport use in the urban areas free or inexpensive, while collecting a transit fee for more remote areas depending on distance. However, if the likelihood of moving to the urban areas was low, the policy would still serve as an incentive for car use. There are also cases where older policies create major issues as times change. In such cases, it may be possible to solve the problems by eliminating the policies rather than implementing new ones. There are many other similar examples, but the important point when considering the effects of policy is to adequately consider policy combinations.

e. Other points

Other points to consider include fairness, the need for careful road design, the problem of inertia, and technological innovations.

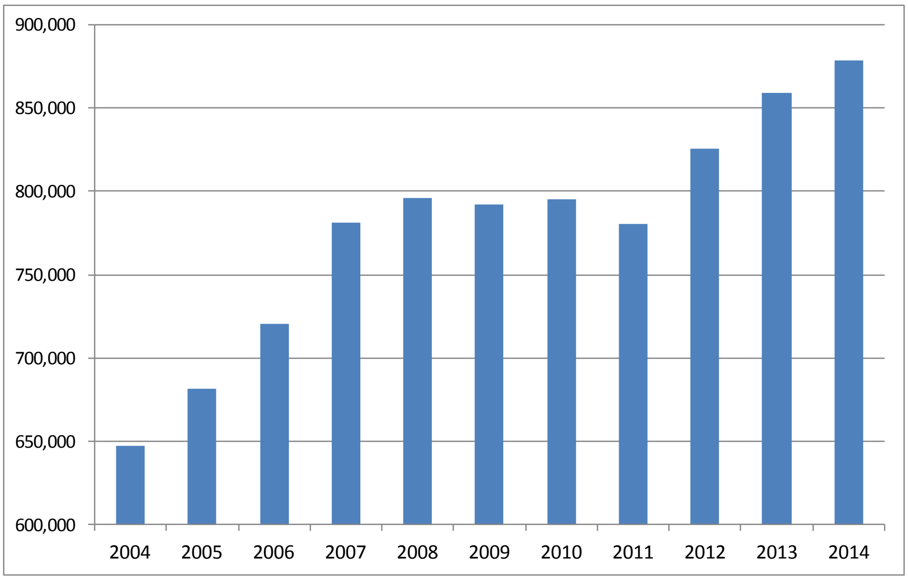
While fairness is certainly important for us, it is also true that its application must be limited. One needs to be careful to apply fairness unconditionally in infrastructure development even in sparsely populated areas. As in the case of housing, it must be understood that fairness also involves a certain degree of arbitrariness.

Also, we have already discussed the risks involved with the careless expansion of roads, and even for changing the routes of roads. For example, simply adding a shortcut can have the effect of reducing overall transport efficiency.[64] Thus it is necessary to work with civil engineers to determine in advance what the effects would be of changing routes.

An understanding of inertia is also important. The Oedo subway line began operating in stages in Tokyo starting in 1991. However, although the line provided more logical routes, many passengers preferred to use the familiar older routes, and it took time for them to switch to using the Oedo line (Figure 2.10). This underscores that it takes time to change people's habits. Similarly, when attempting a modal shift away from automobiles, is important to create a new habit of using public transport.

[64] This is called Braess' Paradox and it is said that this phenomenon occurs in Manhattan, Oslo, and Stuttgart.

Figure 2.10: Changes in Daily Passenger Numbers on the Oedo Line in Tokyo



Source: Tokyo Metropolitan Bureau of Transport.
http://www.kotsu.metro.tokyo.jp/information/service/subway.html

Advances in technology can also provide major breakthroughs. The development of new systems, such as Uber and Lyft, has the potential to provide efficient transit methods in areas with low density. In California, some traditional taxi companies have gone out of business, and this phenomenon is likely to spread to other low-density areas. However, new technologies also give rise to new problems. For example, taxi dispatch systems brought about a proliferation of unlicensed taxis. Thus, when promoting technological innovation, it is also necessary to adequately consider the problems it may cause. Policy that leverages market competition is also extremely important, but competition should be kept at a sustainable level in light of the special characteristics of the public transport industry.

f. Policies from the viewpoint of the citizens

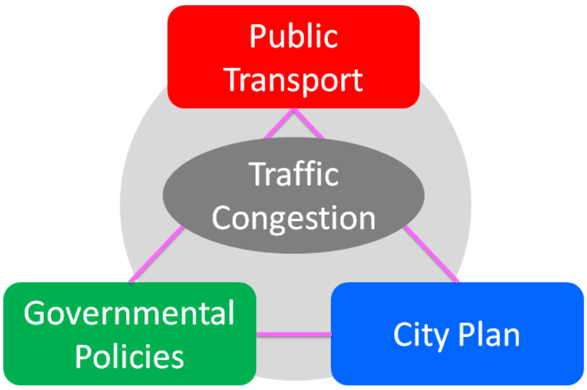
Finally, citizens' involvement and acceptance are an important factor in the success of policy. Some policy makers try to prepare high-minded policies that may, for example, benefit the environment or national security. However, even if the general public can understand such policies and the motivation behind them, they may not change their behaviour. Few would trade their own money or safety for environmental benefits. Similarly, most would not take action that would benefit national security unless the problem is apparent in their own region. In this sense, it is necessary for the policy maker to provide a message to the public that policy will lead to the high level of service and comfort that the general public aspires to, or to keep in mind the implementation of policy that does actually improve those things.

It is meaningless to solely pursue the achievement of numerical policy targets. Rather, a policy must stand on the basis of seeking greater welfare for general public. The precondition for improving energy efficiency in transport is that it ultimately contributes to the development of a comfortable society by making the lives of the people more abundant and increasing their safety and convenience. In this light, policy will be successful only when it can involve citizens and gain their acceptance.

7. Summary

To recap, the requirements for dealing appropriately with traffic congestion are an excellent public transport system, appropriate government policies, and the design of smart transport-oriented cities (Figure 2.11). To realise a rational transport system, it is necessary to develop comprehensive transport policies by working jointly in those three domains.

Figure 2.11 Diagram of Comprehensive Transportation Policy



Source: Study team.

Table 2.2: List of Considerations for Transport Policy

Item	Specific Improvement Points
Public Transportation Design	
Rapidity	Equipment (trains, tracks, management systems); dedicated lanes; access; operation frequency; operation punctuality; transfers; ease of transit through stations
Safety	Vehicle (specifications, interior structure, impact resistance); maintenance; safety devices; dedicated lanes; driver skill; labour environment
Comfort	Interior temperature and humidity; drive safety; elimination of unpleasant factors (noise, odours, air contamination, crime)
Infrastructure investment	Recovery of the external economy (taxation and subsidies, real estate development)
Price and competition	Full-cost pricing, franchising, yardstick, price cap, congestion charges, peak load pricing
Public–private cooperation	Public–private partnership, private finance initiative, concession, management commission, build–operate–transfer, etc.
Application issues	Automation, information and communication technology, internet, integrated circuit cards, station development, attracting universities and factories to the suburbs, handling tourists, collaboration with the community
City Policy	
Design	Urban planning (land zoning, height limits, floor area ratio, building to land ratio); high-rise buildings; preparing spacious and comfortable walking and bicycling routes; ample space between buildings; construction of parks and libraries; securing population fluidity
Tax policy	Handling of commuting costs and housing subsidies, residency tax, property tax
Infrastructure	Pricing that reflects population density, withdrawal from inefficient areas
Transport Policy	
Taxation	Types: Gasoline tax, automobile acquisition tax, automobile tariffs, licensing fees Considerations: Taxation effects, speed of taxation effects, application of tax revenue, taxation timing
Regulations	Clarify purpose and method, side effects, the problem of effectiveness and cost
Subsidies	Effectiveness of subsidies, the problem of dependency on subsidies
Combination	The three patterns of policy effects, the principle of problem simplification
Other	Fairness, altering roads, inertia, technological innovations, citizen’s viewpoint

Source: Study team.

Each domain is an important element in its own right, and at times there may be pressure to compete with the others to maximise a domain. At these times it is particularly important for the policy maker to return to the initial goal of realizing balanced and efficient transport by examining the overall picture with a wide-ranging and long-term outlook. In addition to the benefits to the economy and company competitiveness, the construction of an excellent transport system can make a major contribution to reducing the physical and psychological burden of travel for local residents, and to the realisation of excellent cities. Table 2.2 provides a summary of the considerations for any transport policy.

CHAPTER 3

Modal Preference of Da Nang Citizens

1. Stated Preferences Survey

The study conducted a stated preferences survey to understand the modal choice behaviour of Da Nang citizens and develop a modal split model. The survey was conducted during 7–12 November 2015. Four survey locations were selected (Figure 3.1). Respondents were chosen from each area using the random sampling method and were interviewed to determine the following information:

(i) Trip information (purpose, origin and destination, mode, travel time, travel cost and reason of modal choice)

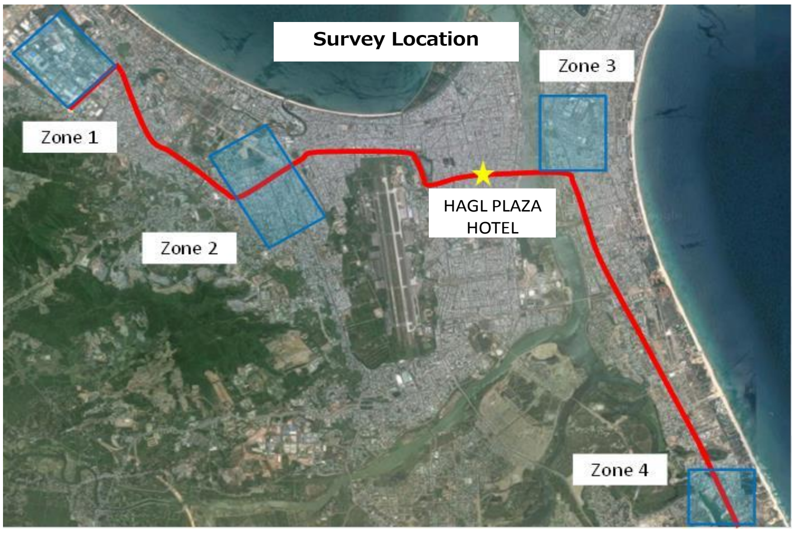
(ii) Alternative transport mode (travel time and travel cost)

(iii) Stated preference on transport mode

(iv) Personal information (gender, age, car or/ motorcycle ownership, driving licence ownership, daily use mode, preference to use BRT, and income)

The survey collected 1,296 samples using the questionnaire form in Figure 3.2.

Figure 3.1: Survey Locations in Da Nang City



Zone 1: Lien Chieu District

Zone 2: Lien Chieu District and Cam Le District

Zone 3: Son Tra District

Zone 4: Ngu Hanh Son District

Source: Study team.

Figure 3.2: Survey Form

Questionnaire on Modal Choice in Da Nang City Urban Area

Area Code (Zone xxx)

- Survey date:________________________
- Surveyor's name:_______________________________

This is a questionnaire survey about a new bus rapid transit (BRT) system that will open in the future. It aims to understand the modal choice behavior in Da Nang City urban area to assist in forecasting transportation demand. We will only use the information you provide for this purpose. We will not reveal your personal information and will only provide the questionnaire survey results in statistical form. Thank you for your cooperation.

1. Question about your modal choice behavior at present.

1.1. Please answer about mode of transportation and travel time that you usually use from your home to any destinations in the using order. And if you use public transportations, please answer these costs, travel time, waiting time and location.

Travel Purpose : ☐ Home - Office ☐ Home - School Home – Shopping Place

Origin | Location : | Waiting Time (min) :

Mode of Transportation : ☐ Walk ☐ Bicycle ☐ Private Car ☐ Private Motorcycle ☐ Motorcycle Taxi ☐ Taxi ☐ Bus ☐ Railway | Travel Time (min) : | Cost (VND) :

Transfer Location or Destination | Location : | Waiting Time (min) :

Mode of Transportation : ☐ Walk ☐ Bicycle ☐ Private Car ☐ Private Motorcycle ☐ Motorcycle Taxi ☐ Taxi ☐ Bus ☐ Railway | Travel Time (min) : | Cost (VND) :

Transfer Location or Destination | Location : | Waiting Time (min) :

Mode of Transportation : ☐ Walk ☐ Bicycle ☐ Private Car ☐ Private Motorcycle ☐ Motorcycle Taxi ☐ Taxi ☐ Bus ☐ Railway | Travel Time (min) : | Cost (VND) :

Transfer Location or Destination | Location : | Waiting Time (min) :

Mode of Transportation : ☐ Walk ☐ Bicycle ☐ Private Car ☐ Private Motorcycle ☐ Motorcycle Taxi ☐ Taxi ☐ Bus ☐ Railway | Travel Time (min) : | Cost (VND) :

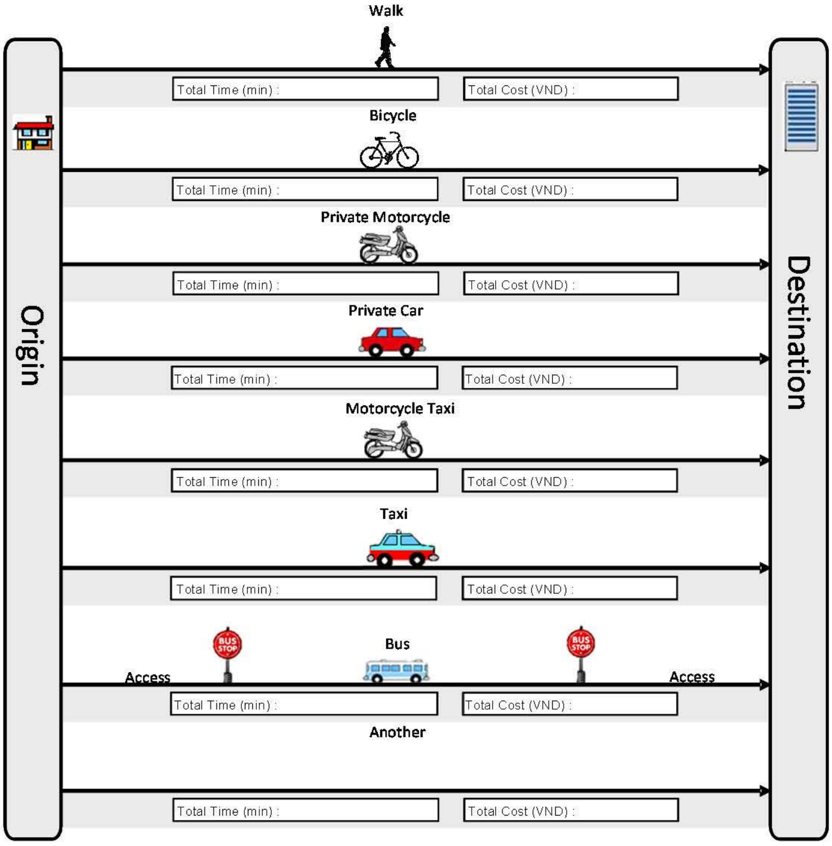
Transfer Location or Destination | Location : | Waiting Time (min) :

1.2. Why do you choose modes above? Please select the most appropriate reason for you.

☐Travel Cost ☐Reliability/ Punctuality ☐Travel Time

☐Convenience ☐Safety ☐Comfort

1.3. Please estimate travel time and cost of each of the following modes. (Travel purpose and destination is the same as Question No. 1.1.)



1.4. Please select some of the following modes that you might use for your travel purpose. (Travel purpose and destination is the same as Question No. 1.1.)

□  Private Car

□  Private Motorcycle

□  Taxi

□  Bus

□  Motorcycle Taxi

2. The new BRT system will open near here in the future. Please describe your expected modal choice behavior once the BRT is open under each of the following three cost and time scenarios. Assume the HAGL Plaza Hotel is your destination.

If travel time, costs, transfer frequency and so on of each mode of transportation is as follow, which transport mode do you choose? (*Please select the most appropriate mode for you*)

Case 1

1.1

Modes	Total time [min]	Total Cost [VND]	Breakdown of (2) & (3) include the below			
			Access Time [min]	Waiting Time [min]	Acces Cost [VND]	Parking Cost [VND]
(1)	(2)	(3)	(4)	(5)	(6)	(7)
□ 1. Motorcycle	30	11, 800				5, 000
□ 2. Car	30	107, 700				12, 500
□ 3. Bus	28	5, 000	4	10		
□ 4. BRT	21	6, 000	4	3		
□ 5. Motorcycle + BRT	21	10, 250	1	3	250	4, 000
□ 6. Feeder Bus + BRT	21	6, 000	1	3	0	

Case 2

1.2

Modes	Total time [min]	Total Cost [VND]	Breakdown of (2) & (3) include the below			
			Access Time [min]	Waiting Time[min]	Acces Cost [VND]	Parking Cost [VND]
(1)	(2)	(3)	(4)	(5)	(6)	(7)
□ 1. Motorcycle	30	10, 800				4, 000
□ 2. Car	44	105, 200				10, 000
□ 3. Bus	30	5, 000	8	5		
□ 4. BRT	27	5, 000	8	5		
□ 5. Motorcycle + BRT	24	5, 500	2	5	500	0
□ 6. Feeder Bus + BRT	26	9, 000	2	5	4, 000	

Case 3

1.3

Modes	Total time [min]	Total Cost [VND]	Breakdown of (2) & (3) include the below			
			Access Time [min]	Waiting Time[min]	Acces Cost [VND]	Parking Cost [VND]
(1)	(2)	(3)	(4)	(5)	(6)	(7)
□ 1. Motorcycle	30	10, 800				4, 000
□ 2. Car	44	105, 200				10, 000
□ 3. Bus	30	5, 000	8	5		
□ 4. BRT	27	5, 000	8	5		
□ 5. Motorcycle + BRT	24	9, 500	2	5	500	4, 000
□ 6. Feeder Bus + BRT	26	5, 000	2	5	0	

Why did you choose the mode above? Please select the most appropriate reason for you each case.

Case 1 ☐Travel Cost ☐Reliability/ Punctuality ☐Travel Time
☐Convenience ☐Safety ☐Comfort

Case 2 ☐Travel Cost ☐Reliability/ Punctuality ☐Travel Time
☐Convenience ☐Safety ☐Comfort

Case 3 ☐Travel Cost ☐Reliability/ Punctuality ☐Travel Time
☐Convenience ☐Safety ☐Comfort

3. Finally, please provide the following personal information.

3.1 Please answer about your sex.

☐ Male ☐ Female

3.2 Please answer about your age.

☐ under 10's ☐ 10's ☐ 20's ☐ 30's

☐ 40's ☐ 50's ☐ over 60's

3.3 Do you have a car license?

☐ Yes. ☐ No.

3.4 Do you have a private car?

☐ Own car ☐ Family car ☐ No.

3.5 Do you have a motorcycle license?

☐ Yes. ☐ No.

3.6 Do you have a private motorcycle?

☐ Own motorcycle ☐ Family motorcycle ☐ No.

3.7 Please answer about mode of using main transportation when you come home in your daily life.

☐ Bicycle ☐ Motorcycle ☐ Taxi ☐ Motorcycle Taxi

☐ Car ☐ Bus ☐ Railway

3.8 If BRT will open near your home, do you want to use that Line?

☐ Yes. ☐ No.

3.9 Please answer about income of your family. (1000 VND/Month)

☐ ~1,999VND ☐ 2,000~5,999VND ☐ 6,000~9,999VND ☐ 10,000~13,999VND

☐ 14,000~19,999VND ☐ 20,000~25,999VND ☐ 26,000~39,999VND ☐ 40,000VND~

3.10 Please answer about your personal income. (1000 VND/Month)

☐ ~1,999VND ☐ 2,000~3,999VND ☐ 4,000~5,999VND ☐6,000~7,999VND

☐ 8,000~9,999VND ☐ 10,000~11,999VND ☐ 12,000~13,999VND ☐ 14,000VND~

3.11 Please answer about your occupation

☐ Office Worker ☐ Self-employed ☐ Civil Officer ☐ Part-time Worker

☐ Student ☐ unemployed ☐ Other

Thank you for your cooperation.

Note: For Question, 27 combinations of assumptions (travel time and cost for each mode) were prepared by zone (four locations) and by area (four areas) to obtain a wide range of preferences.
Source: Study team.

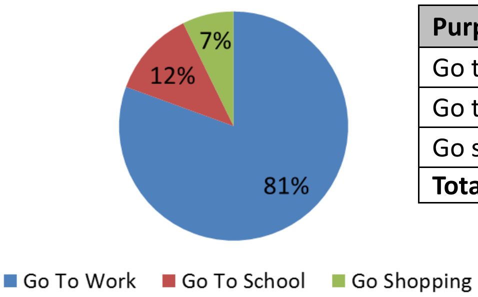
2. Survey Results

2.1 Information on daily trips

The following figures show the results regarding daily travel of respondents. 'Go to work' accounted for 81 percent of all trip purpose (Figure 3.3). 'Go to school' accounted for 12 percent and 'Go shopping' made up 7 percent. Most of the respondents uses private motorbikes as their mode of transport for their daily travel, while only a few uses buses, bicycles, and private cars (Figure 3.4).

Figure 3.5 lists the reasons for the choice of transport mode. Convenience was the dominant reason selected by 88 percent of the respondents; comfort and travel cost were selected by fewer than 5 percent.

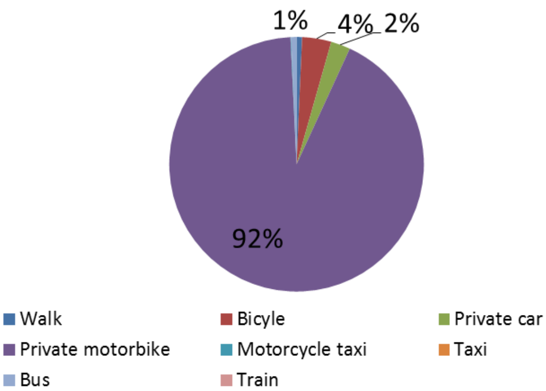
Figure 3.3: Trip Purpose



Purpose	Sample	%
Go to work	1,044	80.56
Go to school	158	12.19
Go shopping	94	7.25
Total	**1,296**	**100**

Source: Study team.

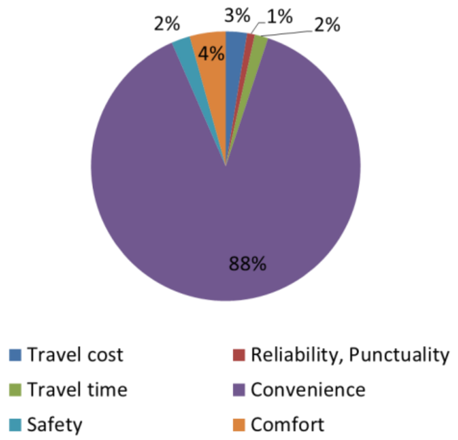
Figure 3.4: Transport Mode



Transport Mode Used for Trip Purpose in Figure 3.3	Sample	%
Walk	9	0.69
Bicycle	48	3.70
Private car	32	2.47
Private motorbike	1197	92.36
Motorcycle taxi	1	0.08
Taxi	0	0.00
Bus	9	0.69
Train	0	0.00
Total	**1,296**	**100.00**

Source: Study team.

Figure 3.5: Reason for Selection of Transport Mode



Reason for Selection of Transport Mode in Figure 3.4	Sample	%
Travel cost	33	2.55
Reliability, punctuality	12	0.93
Travel time	21	1.62
Convenience	1,145	88.35
Safety	29	2.24
Comfort	56	4.32
Total	**1,296**	**100**

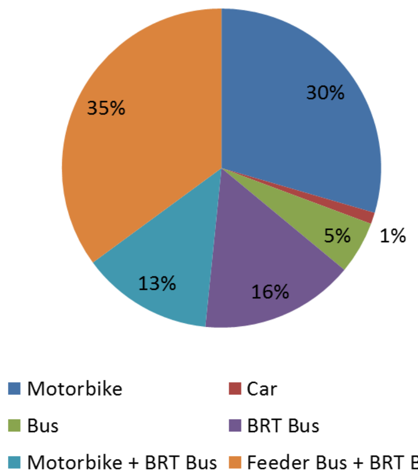
Source: Study team.

2.2 Results of stated preferences

In the questionnaire, respondents were interviewed to select one that they prefer out of six modes with various combinations of travel time and cost. Three cases were given in order to develop the modal split model.

Figure 3.6 shows the results of mode selection based on the assumed travel conditions for each transport mode. The 'Feeder bus and BRT bus' was selected by 35 percent. 'Motorcycle,' 'BRT bus,' and 'Motorcycle and BRT bus' are 29 percent, 15 percent, and 13 percent, respectively. The results, though, do not show a preference of modal choice directly because the combination of travel time and cost of each mode varies by case.

Figure 3.6: Selected Transport Mode



Selected Mode in Cases 1, 2, and 3	Sample	%
Motorbike	1,148	29.53
Car	45	1.16
Bus	207	5.32
BRT Bus	607	15.61
Motorbike + BRT Bus	517	13.30
Feeder Bus + BRT Bus	1,364	35.08
Total	**3,888**	**100**

Source: Study team.

2.3 Respondents' personal information

Tables 3.1–3.6 present information about the respondents. These results show that a wide selection of citizens was surveyed.

Table 3.1: Gender

Gender	Sample	%
Male	699	53.9
Female	597	46.1
Total	**1,296**	**100**

Source: Study team.

Table 3.2: **Age**

Age	Sample	%
Under 10	2	0.2
in 10's	8	0.6
in 20's	388	29.9
in 30's	503	38.8
in 40's	271	20.9
in 50's	112	8.6
in 60's	12	0.9
Total	**1,296**	**100**

Source: Study team.

Table 3.3: **Car Driving License Ownership**

Car Driving License Ownership	Sample
Yes	146
No	1,150
Total	**1,296**

Source: Study team.

Table 3.4: **Motorcycle Driving License Ownership**

Motorbike Driving License Ownership	Sample
Yes	1,204
No	92
Total	**1,296**

Source: Study team.

Table 3.5: Monthly Personal Income

Monthly Personal Income (VND per month)	**Sample**
1999	48
2,000–3,999	368
4,000–5,999	473
6,000–7,999	156
8,000–9,999	52
10,000–11,999	34
12,000–13,999	8
>14,000	19
No choice	138
Total	**1,296**

Source: Study team.

Table 3.6: Profession

Profession	**Sample**	**%**
Employee	797	61.50
Self-employed	171	13.19
Government employee	138	10.65
Part-time employee	36	2.78
Student	147	11.34
Unemployed	7	0.54
Total	**1,296**	**100**

Source: Study team.

3. Modal Split Model

A multinomial logit model was adopted as a modal split model. The model structure and model equation are described below. Based on the results of the SP survey, the parameters of this model were estimated.

$$P_{in} = \frac{\exp[V_1]}{\exp[V_1] + \exp[V_2] + \cdot \cdot \cdot + \exp[V_i]}$$

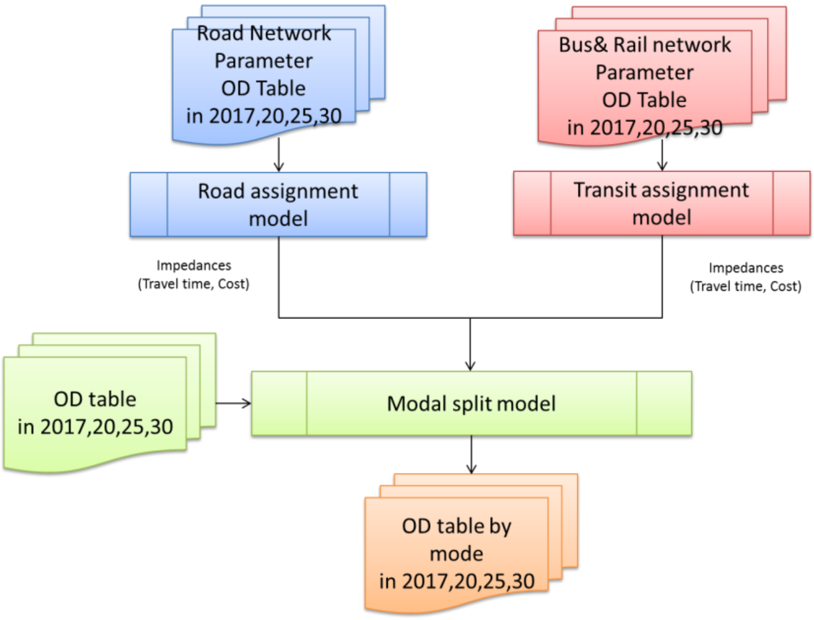
$$V_i = \beta_1 Z_1 + \beta_2 Z_2$$

Where:
P_{in}: Choice probability of mode i
V_i: Utility index of mode i
Z1: Travel time of mode i (min)
Z2: Travel cost of mode i (VND)

β1: Parameter, –0.036
β2: Parameter, –0.0000206

The model was used to calculate the modal shares in the future years. Figure 3.7 shows the flow of modal share calculation. Travel time and travel cost by mode, which are input data of the modal split model, were calculated by road and transit assignment models. However, travel time and travel cost by mode would change because of the future transport network and its level of services. In this study, those conditions were assumed with reference to related documents and the current situation, as shown in Tables 3.7–3.9.

Figure3.7: Flow of Modal Share Calculation



OD = origin–destination.
Source: Study team.

Table 3.7: **Public Transport Network**

Mode	Route		2015	2017	2020	2025	2030
BRT	BRT1	Khu CN Hoa Khanh–CD Viet Han		○	○	○	○
	BRT2	Cau Song Han–Tran Dai Nghia			○	○	○
	BRT3	Tho Quang–C. vuot Hoa Cam				○	○
	BRT4	Kim Lien–BX phia Nam				○	○
BRT Standard BUS	BRTR1	San bay quoc te Da Nang–Hoi An			○	○	○
	BRTR2	Tho Quang–San bay quoc te Da Nang			○	○	○
	BRTR3	San bay quoc te Da Nang– Ba Na			○	○	○
Metro	Metro1	NH Trung Vuong–Lien Chieu					○
Bus	R1	BX Da Nang–Hoi An	○	○			
	R2	Kin Lien–CD Viet Han	○	○			
	R3	BX Da Nang–TT hanh chinh Hoa Vang	○	○			
	R4A	Da Nang (Cau Thuan Phoc)–Tam Ky (BX phia Nam)			○	○	○
	R5	Nguyen Tat Thanh–Trien Lam Quoc te		○	○		
		Ga DS moi–Trien Lam Quoc te				○	○
	R5	Nguyen Tat Thang–Xuan Dueu			○		
	R6A	BX Da Nang–BX My Son (BX phia Nam)	○	○			
		Nguyen Tat Thanh–BX phia Nam			○	○	○
	R7	Cau Thuan Phuoc–Cau Cam Le		○		○	○
		Cau Thuoc Phuoc–Tran Dai Nghia			○		
	R7	Xuan Dieu–Pham Hung			○		
	R8	Tho Quang–CMT8 (Nguyen Huu Tho)		○	○	○	○
	R8	Tho Quang–Pham Hung			○		
	R9	Tuyen du lich–Ba Na		○			
		Ga duong sat moi–Tien Son (Nguyen Thanh Y)			○	○	○
	R10	Nguyen Tat Thanh–My Khe		○			
		Tho Quang–Cau Vuot Hoa Cam			○	○	○
	R11	Tho Quang–Cam Le		○			
		Tho Quang–Ong Ich Duong			○	○	○
	R11	Xuan Dieu–Lotte mart			○		
	R12	Nguyen Tat Thanh–Hoa Hai			○	○	○
	R12	Tho Quang–Truong Sa			○		
	R13	Vanh dai nam Thanh pho			○	○	○
	R14	Trung tam thanh pho–khu CNC			○	○	○
	R15	BX Da Nang–Tho Quang			○		
		Nguyen Tat Thanh–Tho Quang				○	○
	R16	Kim Lien–My Khe			○	○	○
	R17A	Cau Thuan Phuoc–TT hanh chinh Huyen Hoa Vang			○	○	○
	R18	Tho Quang–Son Tra			○	○	○
	R19	Nguyen Tat Thanh–khu dan cu Tien Son				○	○
	R20	Nhu Nguyet–Cung the thao Tuyen Son				○	○
	R21	Lang DH–TT Tuyen Son				○	○
	R22	CV 29/3–xa Hoa Phong				○	○
	R23	BX phia Nam–Duong Truong Sa					○
	R24	KCN Thanh Vinh–CV 29/3					○

Sources: Approval of master plan for public passenger transport by bus in Da Nang City for 2013–2020 and vision to 2030.

Table 3.8: **Service Level of Public Transport**

Mode	**Frequency** (per hour)	**Speed** (km/h)	**Fare** (VND/ Trip)
BRT	20	25	8,000
BRT Standard Bus	6	Depend on road traffic volume (Max 18 km/h)	8,000
Metro	12	35	16,000
Bus	3 (2017, 2020) 12 (2025, 2030)	Depend on road traffic volume (Max 18 km/h)	8,000

BRT = bus rapid transit, km/h = kilometre per hour, VND = Viet Nam dong.

Sources: Ticketing, Fares, Subsidy and Management and Operations Review Report, Frequent (Monthly and 'pay As You Go' Smartcard User); approval of ticketing plan and subsidy policy for public passenger transport by bus in Da Nang City from 2015 to 2020, Phase 3; and approval of master plan for public passenger transport by bus in Da Nang City for 2013–2020 and vision to 2030.

Table 3.9: **Speed and Costs of Private Modes**

Mode	**Speed** (km/h)	**Vehicle Operation Cost** (VND/km)	**Parking Fee** (VND)	**Access Time to Destination from Parking Space** (min)
Walk	4	0	0	
Bicycle	Depends on road traffic volume	270	2,000	0
Motorcycle	Depends on road traffic volume	1,500	4,000 (2017, 2020) 12,500 (2025, 2030)	0 (2017, 2020) 5 (2025, 2030)
Car	Depends on road traffic volume	13,000	12,500	5
Bus and motorcycle	Depends on road traffic volume	3,000 (VND per trip)	4000	10

km/h = kilometres per hour, min = minutes, VND = Viet Nam dong.

Source: Study team.

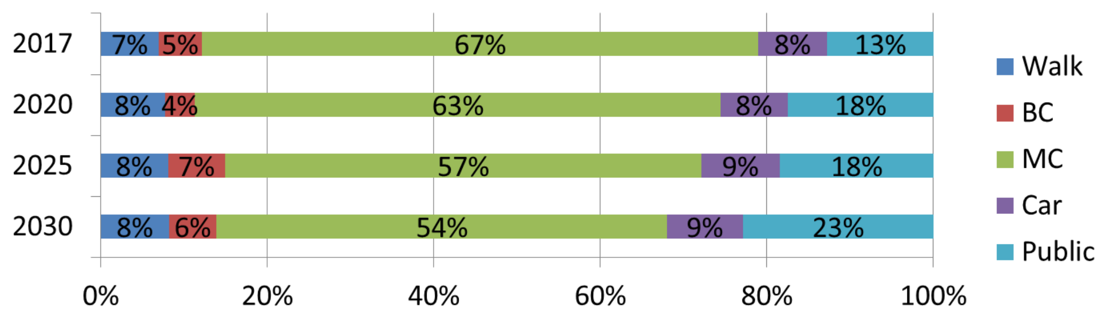
The estimated modal share in the future years is summarised in Table 3.10 and Figure 3.. The number of trips of all modes in 2030 will nearly double compared with 2017. Under the assumed future transport network and level of services, the modal share in Da Nang City will change with the public transport network expanding extensively and then increasing the modal share in 2030 to 23 percent from 13 percent in 2017. The modal share of motorcycles in will decrease to 54 percent in 2030 from 67 percent in 2017. The share of cars will remain the same. The modal share in future years will change based on the transport network and service level provided.

Table 3.10: **Modal Share in Future Years**

Mode	2017		2020		2025			2030
	Trip	%	Trip	%	Trip	%	Trip	%
Walk	131,689	7	172,598	8	238,093	8	283,531	8
Bicycle	96,388	5	79,939	4	200,581	7	194,027	6
Motorcycle	1,255,341	67	1,408,251	63	1,678,569	57	1,859,235	54
Car	154,973	8	178,914	8	276,768	9	311,577	9
Public mode	239,531	13	390,362	18	540,399	18	784,968	23
Total	**1,877,922**	**100**	**2,230,064**	**100**	**2,934,410**	**100**	**3,433,338**	**100**

Source: Study team.

Figure 3.8: **Modal Share in Future Years**



BC = bicycle, MC = motorcycle.
Source: Study team.

Chapter 4

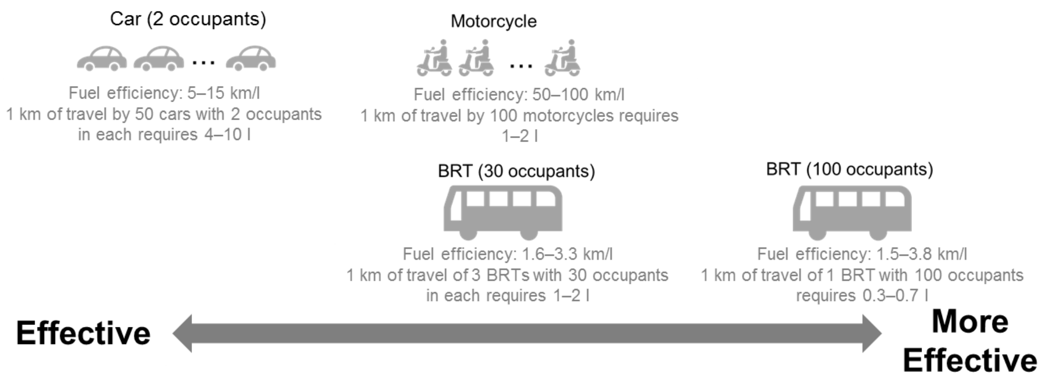
Design and Analysis of Feeder-Line Bus

1. Towards Promotion of Bus Rapid Transit System Use

As Da Nang City has been developing rapidly, like other Asian cities, transport demand is expected to grow significantly. The city is planning to expand and improve roads and public transport, and the introduction of a BRT system is one of the key features. In a BRT system, dedicated BRT lanes give the bus system priority over private transport, allowing the system to carry larger numbers of passengers faster. If used effectively, it could contribute to reducing energy consumption in the transport sector.

As a rough estimate of the energy consumption reduction effect by introducing the BRT system, suppose 100 people travel 1 kilometre (km) along the same road (Figure 4.1). If one person rides on one motorcycle, as is typical in Da Nang City, 100 motorcycles are needed to transport 100 people. When using the BRT, a reduction in fuel consumption of about 60 percent is expected as a bus can accommodate 100 people. Additionally, the BRT is expected to reduce fuel consumption by about 90 percent compared to cars. However, when the number of passengers per vehicle is reduced, the BRT needs as much fuel as motorcycles and the savings are reduced. Therefore, it is important to maximise the number of BRT passengers to improve energy efficiency. Figure 4.1 illustrates the fuel consumption of the different transport modes.

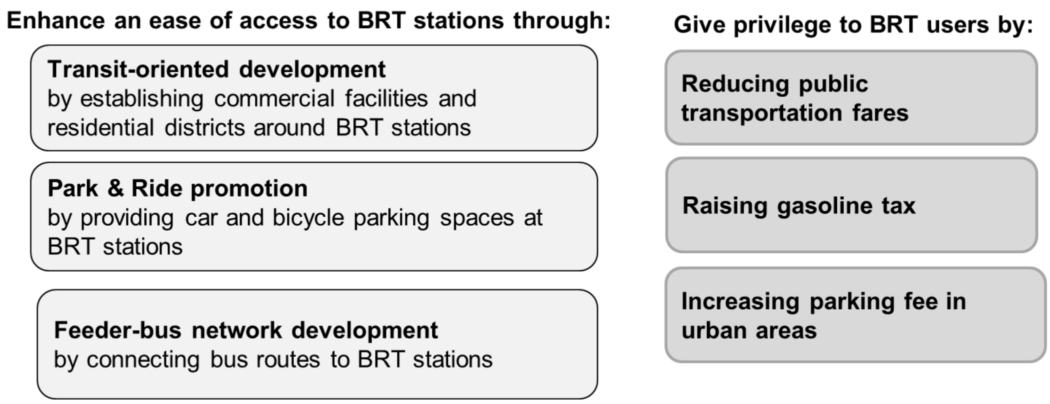
Figure 4.1: **Estimated Fuel Consumption by Transport Mode**



BRT = bus rapid transit, km = kilometre, l = litre.
Source: Study team.

How can we increase the number of passengers who prefer the BRT to motorcycles or cars as means of transport? Possible measures to enhance the attractiveness of BRT are summarised in Figure 4.2. One measure is to improve ease of access to BRT, for example by pursuing transit-oriented development, installing park-and-ride facilities, and establishing feeder bus services. These measures aim to increase the number of potential users that choose the BRT as their mode of transport. However, even if the BRT stations are convenient and close to users, the number of users will not increase if the cost is much higher than that of the private transport, such as motorcycles. Therefore, a second measure is to make BRT use more attractive by making the cost of using BRT lower than that of private transport such as motorcycles and cars. This can be achieved by providing privileges to BRT users by reducing fares, or by penalizing automobile and motorcycle users by raising gasoline tax or increasing parking fees.

Figure 4.2: **Measures to Enhance the Attractiveness of Bus Rapid Transit**



BRT = bus rapid transit.
Source: Study team.

Generally, greater impact can be achieved by implementing a well-balanced combination of measures rather than using any one of them individually. It is technically difficult to evaluate the future effects of all measures quantitatively, so the study chose to analyse the impact of a feeder-bus network that Da Nang City is interested in developing.

To conduct a quantitative evaluation on the feeder bus, specific feeder bus routes must be set for the study. Designing such routes requires specialised expertise and experience, therefore, feeder bus routes were decided using the technique developed by authors in a 2015 study.[65] Using this technique, the best bus route and travel frequency can be determined for the given conditions of traffic demand in the city, roads, and the BRT network. When applied actual cities, the technique has some problems such as the difference between the assumed model and reality. Section 2 reviews these issues and refine the technique, and Section 3 evaluates the

[65] Kutani, T., Y. Sudo and Y. Li (2015), 'Preliminary Design and Analysis of Feeder Line Bus, in Energy Efficiency Improvement in the Transport Sector through Transport Improvement and Smart Community. ERIA Research Project Report 2014-31, Jakarta: ERIA, pp. 65–82. Available at: http://www.eria.org/RPR_FY2014_No.31_Chapter_4.pdf

introduction of a feeder bus system by calculating the optimised feeder bus routes using the planned BRT network in Da Nang City as given conditions.

2. Feeder Bus Route Design and Evaluation Method

The technique to design feeder bus routes was developed to obtain the best bus route and calculate the optimal travel frequency under the given conditions. Since the feeder bus facilitates access (or egress[66]) to the main public transport (the BRT in Da Nang City), its coverage must be expanded by setting up routes that connect as many residential areas as possible to BRT stations. Too much expansion, however, could cause unnecessarily expense, which means installing feeder buses is a kind of balance problem.

The technique developed in 2015 uses mathematical programing to deal with the problem. It applies the problem to a mathematical model that minimises sum of all travel times as the objective functions within given constraints in the feeder bus network design. The technique can obtain the feeder bus route that can minimizes the travel time and, as a result, increase the number of passengers who can travel faster by using the public transport. In addition, it sets the upper limit on the total travel distance of the feeder bus as a constraint to preferentially select the most effective route. Limits can also be set on the number of passengers carried per vehicle for buses and the BRT as one of the constraints to determine how many buses are needed to carry all the passengers.

However, this mathematical model differs from reality in the following ways:

- It places constraints on the total travel distance of the feeder bus but it does not do so for cost, even though cost effectiveness is an important consideration. It was therefore decided to find a method to design bus routes using budget constraint instead of travel distance constraint. This is described in section 2.1
- The total travel time is used as the objective function, assuming that passengers choose the transport mode that enables the shortest total travel time. The model is therefore unrealistic because it assumes that time is the only consideration when deciding transport means. In reality, people consider other factors, such as cost, in addition to travel time. Furthermore, the choice of a deterministic model is also unrealistic. In the deterministic model, a person always favours the lower-cost option however minimal the difference is (e.g. the travel time of one option could be one second less than another). In reality, people will choose either transport means if the cost is almost same. However, it is technically difficult to use the probabilistic model that accommodates this kind of decision making in the mathematical programming framework. Therefore, we improved the calculation process, as described in section 2.2.

[66] When using multiple means of transport, transport to the main transport, such as a BRT station, is called access, and a transport to the destination from the main transport is called egress.

2.1 Constraints on Operating Cost of Feeder Bus

In order to represent the budget constraint on the feeder bus by cost rather than by travel distance, the cost is needed for each expense item must be determined. Items to be considered include fuel cost, vehicle purchase cost, and personnel cost. To avoid excessive detail, a uniform cost per unit distance was used. In this way, the cost conversion is easy, and the unit cost per travel distance can be obtained relatively easy by examining past records. According to a Da Nang City official, the cost is VND15,000–16,000/km for a standard 40-passenger bus. This value is used as a rough estimate in this study, although targets are not necessarily limited to 40-passenger buses in the feeder bus design.

2.2 Transport Mode Choice Model

As mentioned earlier, it is difficult to use the probabilistic transport mode choice model in the optimisation calculation. Therefore, we decided to improve the calculation process (Figure 4.3). At first, we use the method built in 2015 to design the feeder bus with the deterministic model considering only the travel time. Then, we evaluated the feeder bus network area obtained using the traffic flow simulator with a probabilistic model considering both cost and time effect. Using the more sophisticated transport mode choice model helps to ensure the appropriateness of the model.

The model built for the Japan International Cooperation Agency Study on Integrated Development Strategy for Da Nang City and Its Neighboring Area Project (DaCRISS) was a candidate for a more sophisticated transport mode choice model for Da Nang City.[67] The model used in the DaCRISS project was built after individual homes were interviewed about transport means used as of 2008. It is therefore considered realistic, even though data are a little old. However, when the model is applied to 2025, when the BRT and the route bus are expected to be well developed, the number of public transport users becomes extremely low (Figure 4.4).

The survey results at the time show that motorcycle and car users accounted for nearly 99 percent and public transport users made up only 0.2 percent (Figure 4.5). The public transport share was low because the bus service was not developed enough to provide sufficient bus routes, and there was no BRT. It is not possible to build an accurate model of public transport mode choice based on this information because there were too few samples to estimate the number of public transport users.

Therefore, section 3 uses a newly built transport mode choice model. As this model is based on the stated preference survey assuming the introduction of the BRT system, it is suitable to evaluate a BRT system that does not yet exist in Da Nang City.

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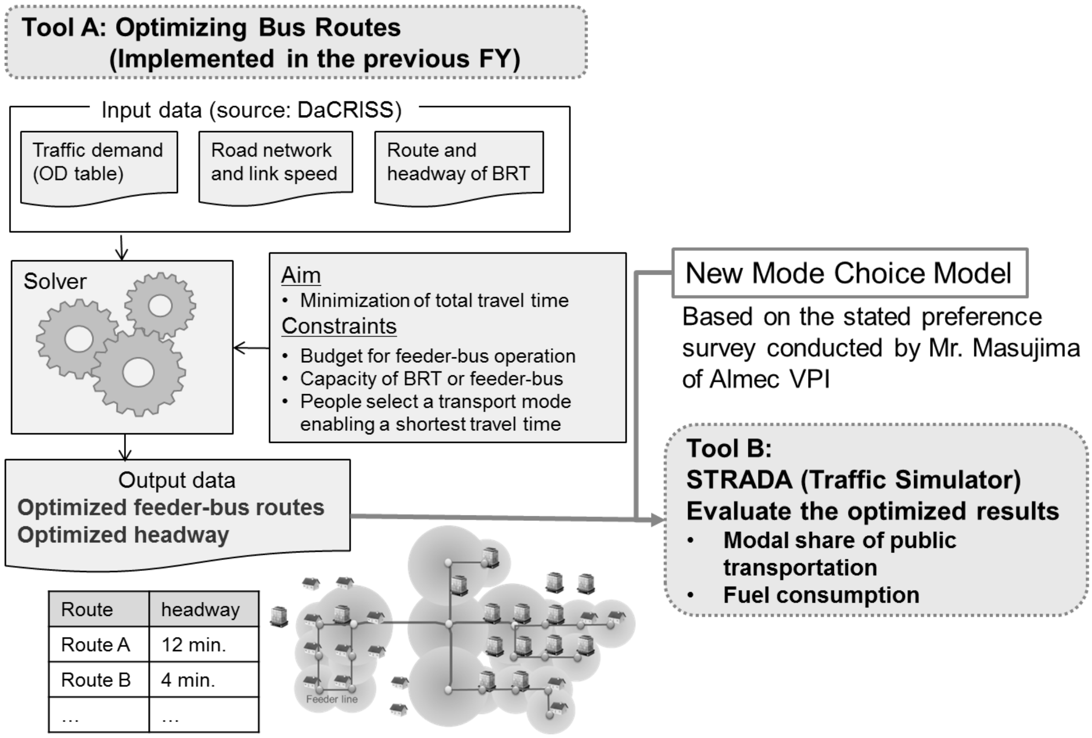
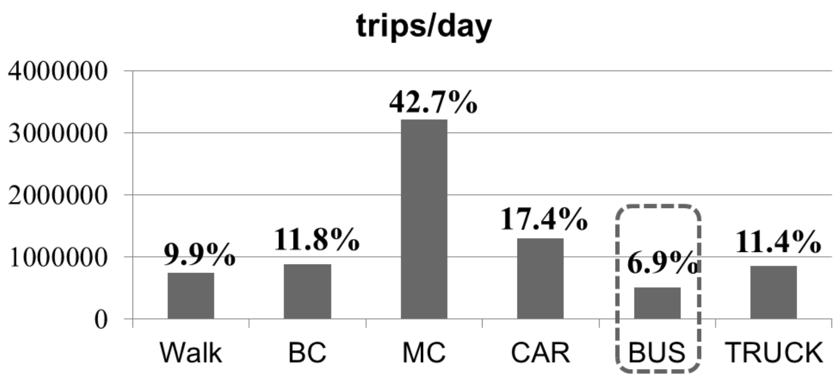
[67] Japan International Cooperation Agency (2010), '*Study on Integrated Development Strategy for Da Nang City and Its Neighboring Area in the Socialist Republic of Vietnam*.' Tokyo.

Figure 4.3: Feeder Bus Simulation Analysis Method



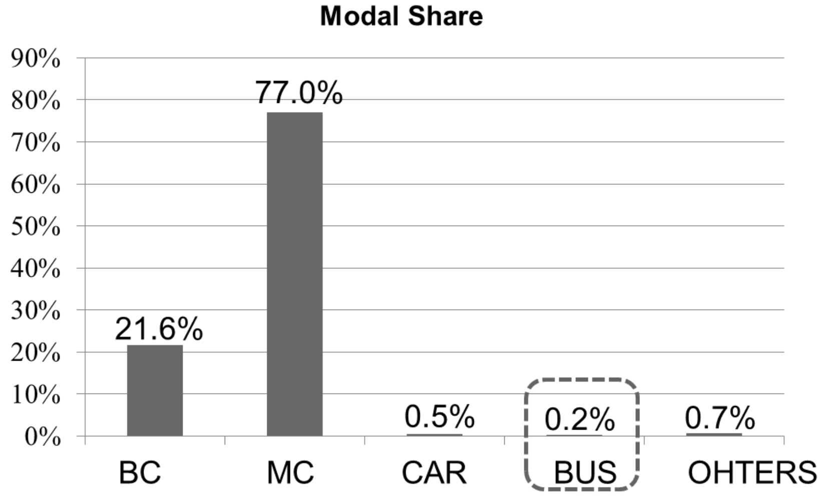
BRT = bus rapid transit, DaCRISS = Study on Integrated Development Strategy for Da Nang City and Its Neighbouring Area Project, FY = fiscal year, min = minutes, OD = origin–destination.
Source: Study team.

Figure 4.4: **Modal Split Using DaCRISS Model, Assuming 2025, Excluding Feeder Bus**



BC = bicycle, DaCRISS = Study on Integrated Development Strategy for Da Nang City and Its Neighboring Area Project, MC = motorcycle.
Source: Study team.

Figure 4.5: **Modal Split, Excluding Walking, as of Individual Home Interview in 2008**



BC = bicycle, MC = motorcycle.
Source: Study team.

3. Optimised Feeder Bus Routes and Simulation Evaluation

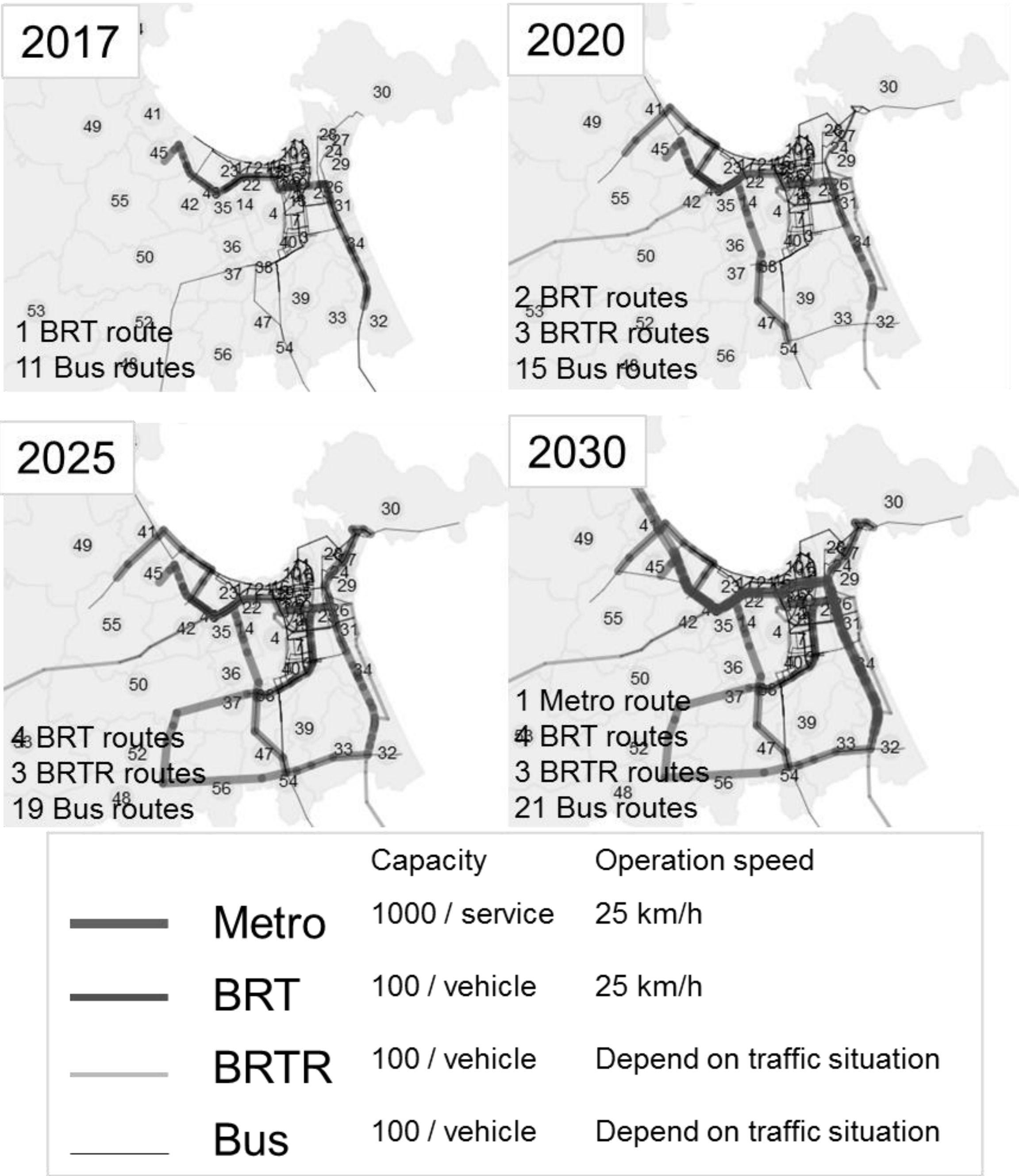
3.1 Preconditions for Analysis

Preconditions for the study to carry out the feeder bus analysis are as follows. According to the transport plan of Da Nang City, the first BRT line will be introduced in 2017, and four more will be implemented in 2025. In addition, metro is scheduled to be introduced in 2030. Metro is a track vehicle that is expected to have 10 times the capacity of the BRT. The target years of the analysis are 2017, 2020, 2025, and 2030.

The analysis uses data on roads and the public transport network sourced from the Da Nang City transport plan. As shown in Figure 4.6, four types of transport are scheduled: BRT, BRT standard bus (BRTR),[68] metro, and bus. Since the metro, BRT, and BRTR are considered to play the role as the main public transport modes, the current plan is used as preconditions. 'Bus' is excluded from preconditions and instead, the feeder bus routes are newly redesigned. To model the future transport demand, the numbers in the DaCRISS Scenario 3 of 2025 multiplied by the rate of population change are used (Figure 4.7).[69] The traffic volume in the entire city (trips between zones) is estimated at about 2 million trips per day, and the figure is expected to almost double to about 3.8 million trips per day in 2030. Figure 4.6, from the city's transport plan, shows how the city intends to cope with the expected sharp increase in traffic volume.

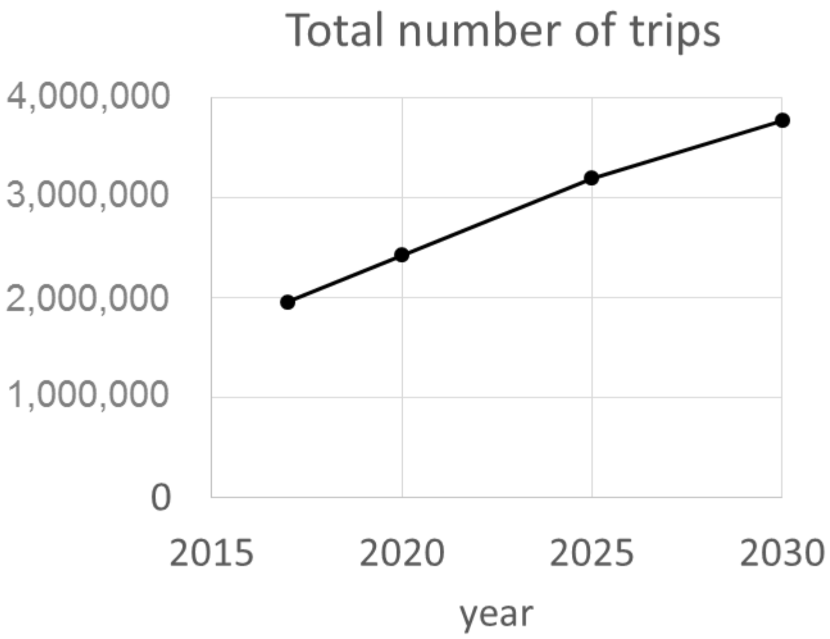
[68] BRTR is a type of bus that is specific to Da Nang City. Although it is positioned as special kind of bus, it is little different from a normal bus given that it does not have dedicated lanes. It is treated here as the main public transport (not the target of optimization) considering its special positioning.
[69] Scenario 3 is one of the urban development visions defined by Da Nang City. The city adopted this scenario that will most accelerate the growth. A population of 2.5 million–3.0 million is assumed in 2030 as the future urban development target.

Figure 4.6: **Da Nang City Transport Plan**



BRT = bus rapid transit, BRTR = BRT standard bus, km/h = kilometres per hour.
Source: Da Nang City transport plan.

Figure 4.7: **Change in Traffic Volume Assumed in DaCRISS**



DaCRISS = Study on Integrated Development Strategy for Da Nang City and Its Neighboring Area Project.
Source: DaCRISS.

3.2. Optimised Feeder Bus Routes

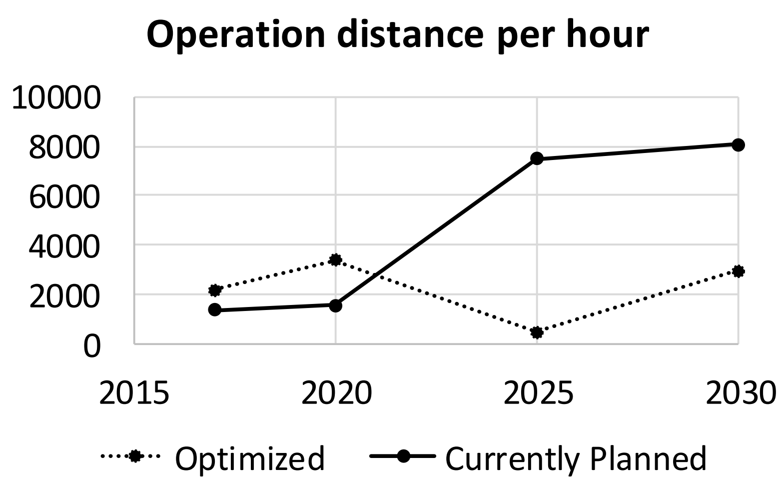
This section describes the calculation of optimised bus routes using certain preconditions Feeder bus routes are designed with large enough (effectively limitless) operating cost constraints. Figure 4.8 shows the calculated operation distance of feeder bus per hour and Figure 4.9 shows the feeder bus routes selected. The operation distance is about 2,000–3,000 km/hour, except in 2025, when it is about 500 km/hour.

The optimised result is compared to the travel distance of the currently planned route bus to evaluate its appropriateness. The total travel distance is about 1,000 km/hour for both. Hence, the optimised route is designed with a similar travel distance to that of the general bus operation plan. As for 2017 and 2020, the travel distance of the plan is about 2,000 km/hour, which is slightly shorter than the optimised result. Under the plan for 2025 and 2030, the travel distance is scheduled to be increased to about 8,000 km/hour. Such a tendency is not shown in the optimised result, which is curious considering the surge in the traffic demand. What could cause of this difference?

The first possibility is the limits of the main public transport capacity. Since the capacity of the BRT is small – about one-tenth that of the metro – it is likely that the BRT reaches its capacity just by carrying residents along its routes. Even if the feeder bus brings more passengers, the BRT might not have extra capacity to carry them. The optimised calculation is designed to add no new feeder bus route if the BRT does not have extra transport capacity, as it considers adding new feeder bus routes a waste of money. Therefore, it is assumed that the feeder bus operation distance cannot be increased due to the BRT transport capacity limit for 2025 and 2030. The same reason seems to apply to why the feeder bus travel distance is extremely small in 2025 in the optimised result. This point needs to be closely considered in the evaluation using the STRADA (traffic flow simulator) later.

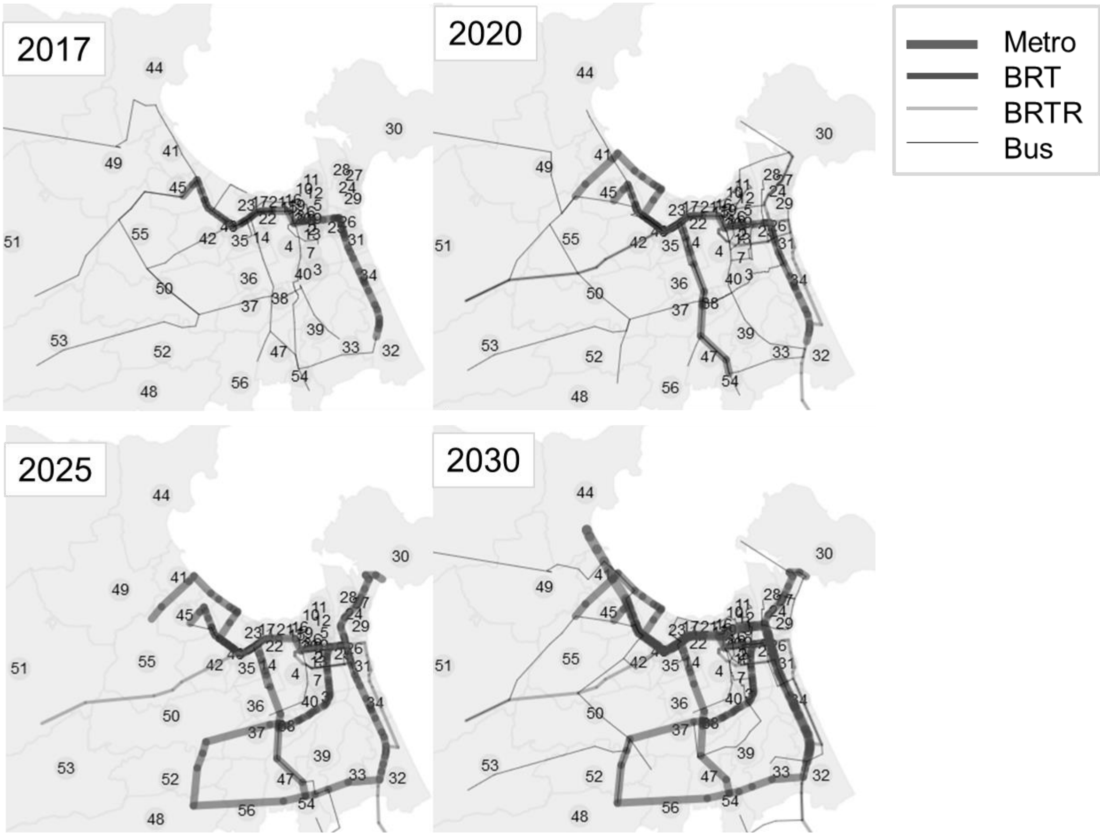
Another reason why the city's plan and the optimised result are different is the trips data used for the calculation.. When comparing the optimised result (Figure 4.9) to the plan (Figure 4.6), the density of the routes in the centre of Da Nang City is largely different. In the plan, there is a high density of routes in the centre of the city, but in the optimised result the density is lower. This is because our calculation used only origin–destination data as a trip demand (i.e., trips from a zone to another zone) because detailed trip data of from a zone to the same zone does not exist. The city's plan, on the other hand, is supposed to have been made based on the experience on the route decision and knowledge of the locality. However, if there is a need to design detailed bus routes, it is necessary to conduct a further research and collect movement data. In any case, the knowledge based on the experience is not included in the data available this time, these issues are not discussed but to be explored in the future.

Figure 4.8: **Optimised Feeder Bus Travel Distance** (kilometres/hour)



Source: Study team.

Figure 4.9: **Optimised Feeder Bus Routes**



Source: Study team.

3.3. Evaluation of Optimised Result Using Traffic Flow Simulation

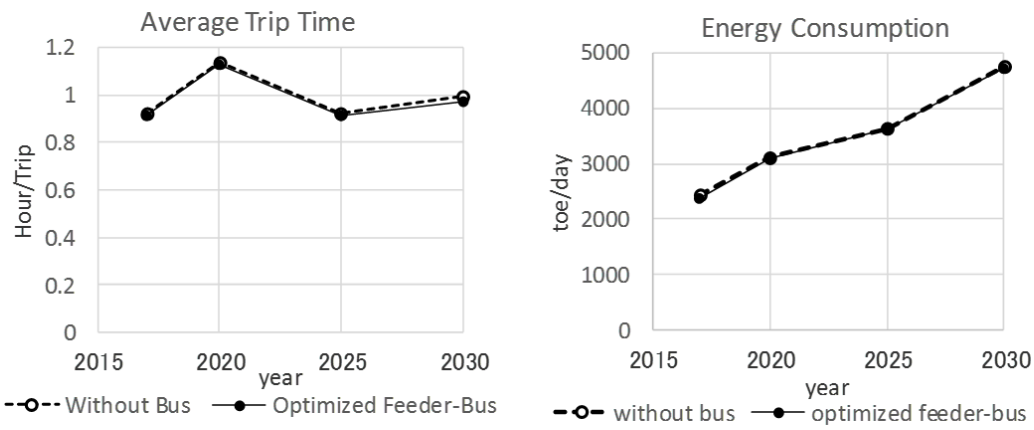
The result of evaluating the obtained feeder bus routes using STRADA is shown below.

First, the average trip time is shown in Figure 4.10 (left). There is almost no difference between when there is no feeder bus (broken line) and when the feeder bus is introduced (solid line). Figure 4.10 (right) shows the effect on energy consumption. Again, there is no difference between the with and without feeder bus route scenarios. These results suggest that adding new feeder bus routes has no effect, but is it really the case?

To answer to this question, the modal split is shown in Figure 4.11. When the feeder bus is introduced, the share of the motorcycle use decreases by several percentage points compared to the case when there is no feeder bus, and the share of the public transport increases accordingly. Therefore, although the introduction of the feeder bus may not immediately reduce fuel consumption, it is likely to change transport means choice behaviour.

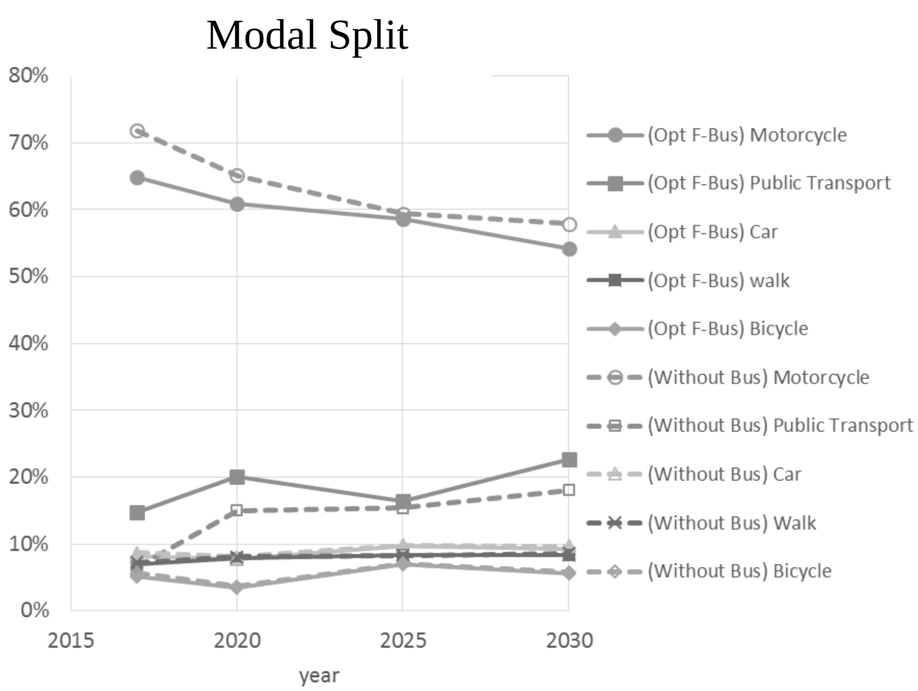
The importance of motorcycles as a mode of transport in Da Nang City is significant. Though it is not considered in this calculation, it is highly likely that overall income levels in Da Nang City will increase and the transport mode will change from motorcycles to cars accordingly. If such a modal shift occurs, it will lead to higher fuel consumption than calculated in Figure 4.10 because the fuel consumption of cars is larger than that of motorcycles. The introduction of feeder buses is significant for fuel consumption as it encourages a shift to public transport by reducing the shift from motorcycles to cars.

Figure 4.10: **Change in Trip Time and Energy Consumption with and without Feeder Buses**



Source: Study team.

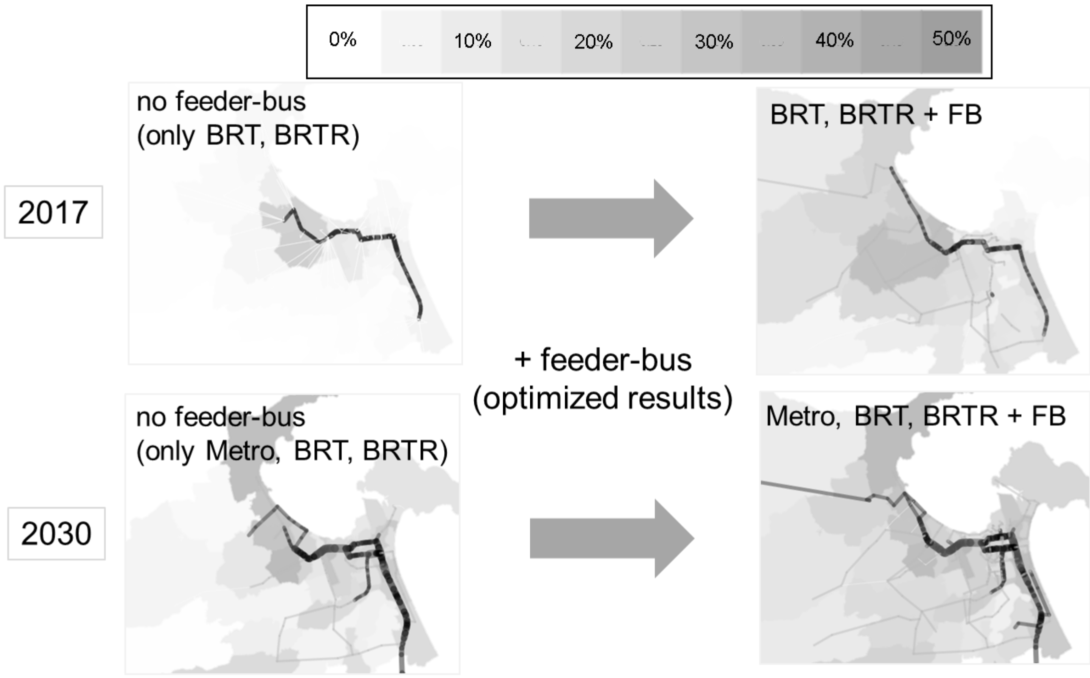
Figure 4.11: Modal Split



Opt = option.
Source: Study team.

Next, to examine the findings in more detail, we illustrate how the introduction of feeder buses affects the modal split of public transport by zone (Figure 4.12). If there is no feeder bus, the public transport share is high only in the areas along public transport routes such as the BRT (10–30 percent). On the other hand, if feeder buses are introduced, the high-share areas are expanded. Without feeder buses, the use of the BRT service will be limited to the residents along the routes, whereas the introduction of feeder buses makes it easier to access the BRT, and the BRT service will be used in wider areas.

Figure 4.12: **Modal Split of Public Transport by Zone**



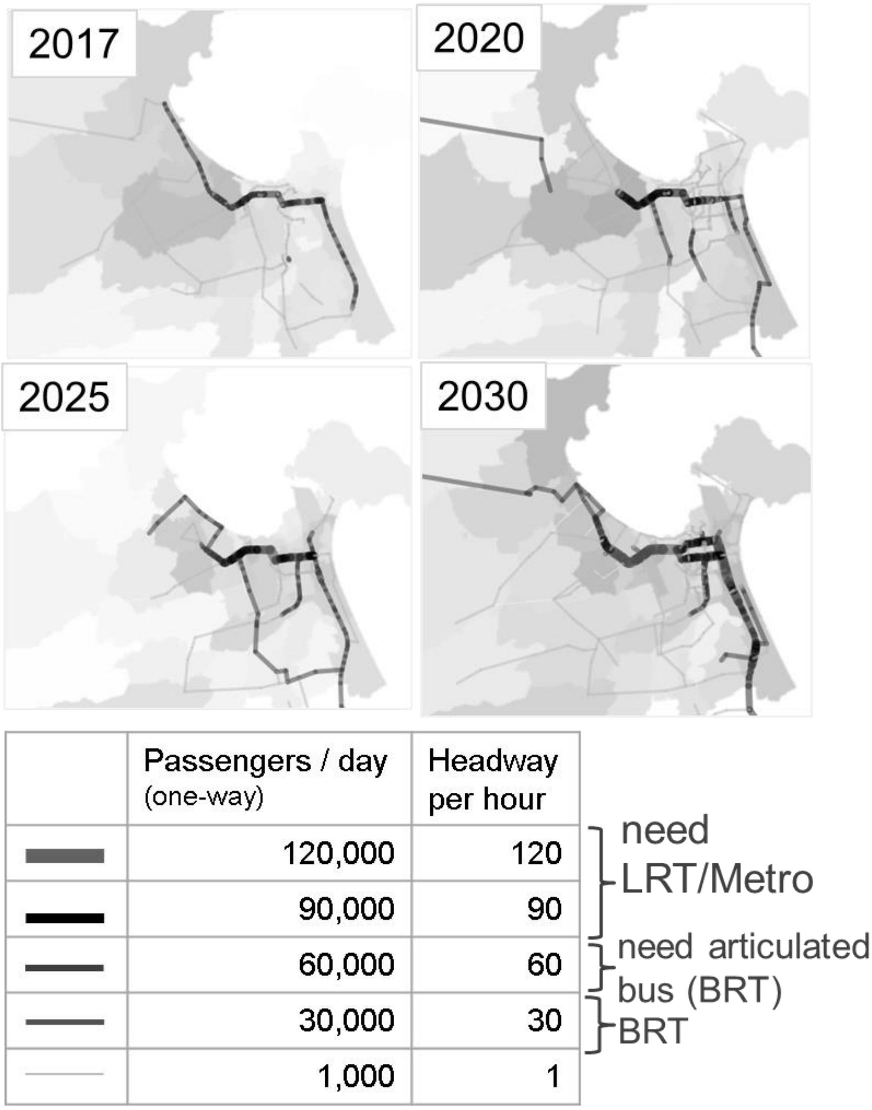
BRT = bus rapid transit, BRTR = BRT standard bus, FB = feeder bus.
Source: Study team.

Figure 4.13 shows the number of passengers boarding public transport on each section of the main transport network. In 2017, immediately after the introduction of the BRT, large numbers of passengers are expected in sections in the centre of Da Nang City. The result indicates the introduction of the articulated bus is necessary to carry such large number of passengers. The number of passengers will further increase after 2020. The number is expected to exceed far beyond the transport capacity in some sections, especially along BRT Line 1. The metro is scheduled to be introduced in 2030, but the simulation result indicates that its timing should be moved forward. If the number of passengers that attempt to use the BRT exceeds its capacity, the attractiveness of the BRT will decrease because of the congestion or the wait time, and the share of public transport will peak. To avoid such a situation, the transport capacity of the BRT should be increased early on.

It is also necessary to consider technical problems of the traffic flow simulator. Because the STRADA simulation computes people's choice of transport mode without considering transport capacity limits and the subsequent congestion, public transport use is overestimated when the demand exceeds supply.

The results enable the following conclusion to be drawn. The transport capacity of the BRT needs to be improved early on. Then, introducing feeder bus services can play an important role to increase the number of BRT users.. In addition, in the evaluation of traffic flow simulation, evaluation techniques that can take the transport capacity into consideration are needed.

Figure 4.13: **Number of Passengers Boarding Main Public Transport Modes, by Section**



BRT = bus rapid transit, LRT = light rail transit.
Source: Study team.

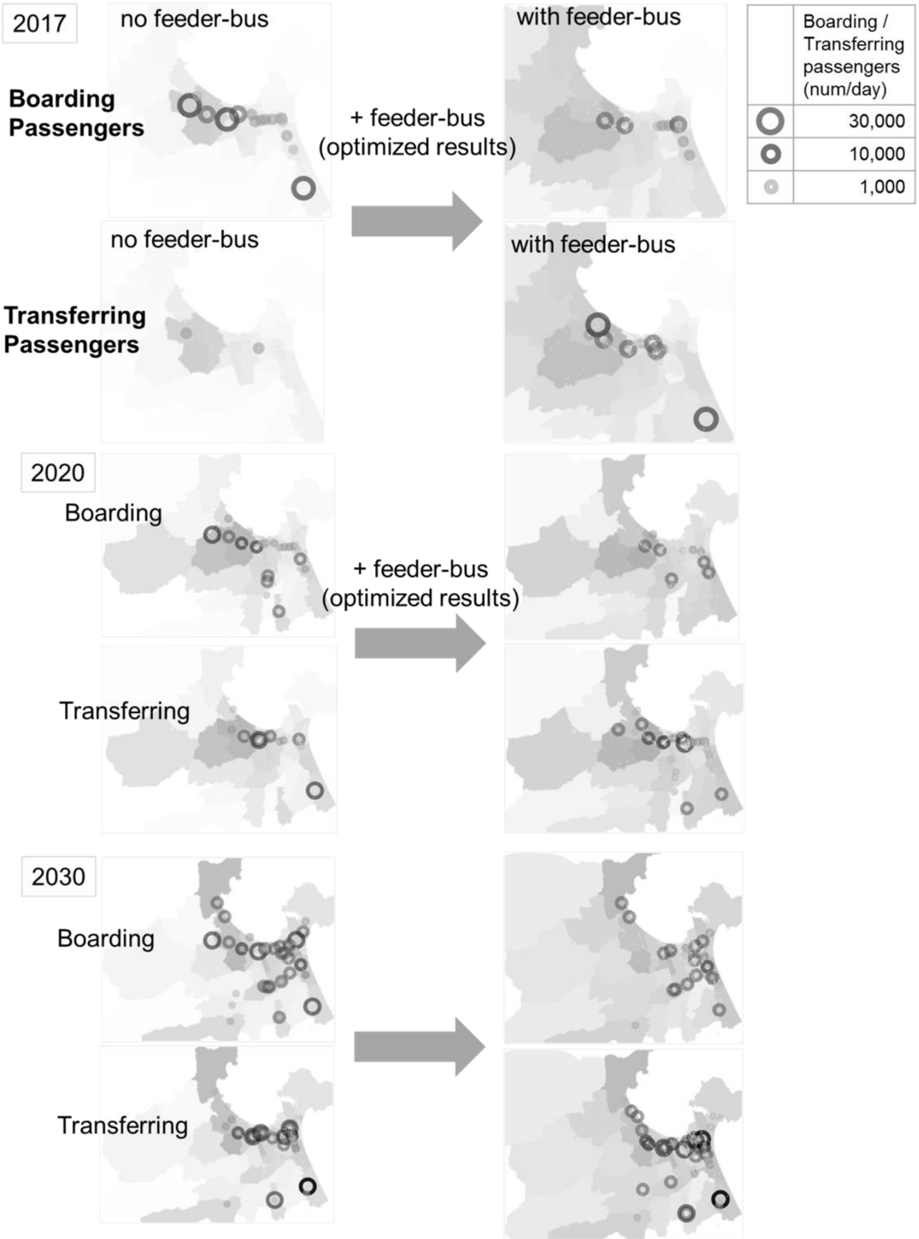
Finally, Figure 4.14 shows the simulation result of how the metro and BRT stations are used. Circles in this figure show the boarding or transferring passengers at each stations. The results for 2017 show that the introduction of the feeder buses tends to reduce the number of boarding passengers at each station and increase the number of transferring passengers. In 2020 and 2030, the introduction of four BRT lines sharply increases the number of passengers who transfer at each station. These findings suggest that the facilities required at stations will change with the introduction of feeder buses and the expansion of the BRT network. Initially, it is important to prepare parking space for motorcycles and cars in front of the station, as most of the passengers are boarding and disembarking from the station. As the public transport network expands, however, the importance of facilities to support smooth transfer increases. The stations with larger number of transferring passengers are hubs for the public transport network. Securing smooth transfer at these main stations could greatly influence the attractiveness of the BRT.

4. Discussion of the Simulation Result

Section 3 discussed the result in the case where there is no constraint on the feeder bus operating cost. What if the constraints are added to the feeder bus operation cost? Figure 4.15 shows the result of optimizing the feeder bus routes by changing the budget in phases and evaluating them using STRADA.

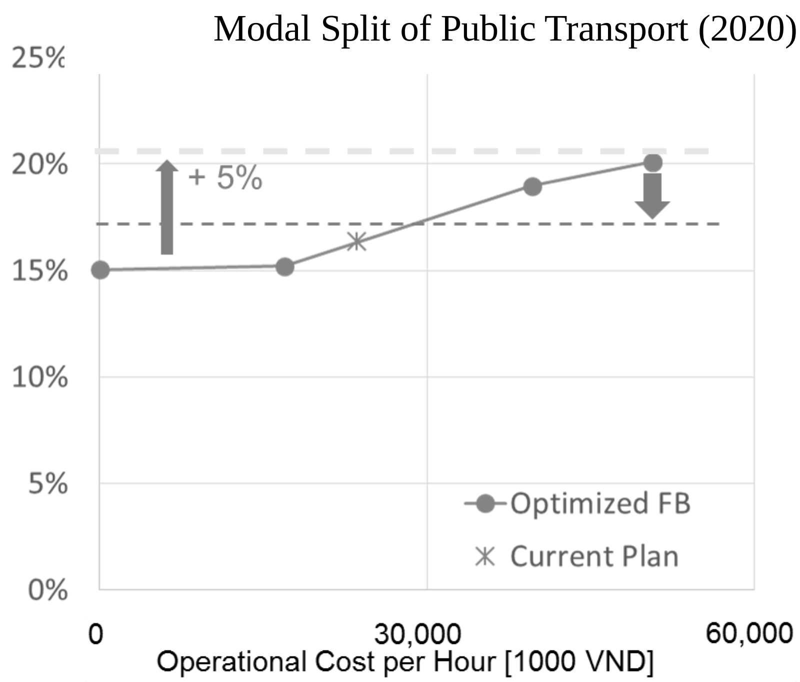
As the feeder bus budget constraint is relaxed and the travel distance increases, the share of public transport increases accordingly. The result shows that in 2020, a 5 percent increase in the share of public transport is expected. However, in reality, as mentioned in Section 3, there is a limit to BRT transport capacity, which is not considered in the STRADA calculation. Thus, the 5 percent increase in the share of public transport is overestimated. To maximise the feeder bus effect, feeder buses need to be used in combination with larger-capacity BRT (BRT using articulated vehicles), light rail transit, or metro.

Figure 4.14: **Number of Passengers by Metro and Bus Rapid Transit Station**



Source: Study team.

Figure 4.15: **Modal Split of Public Transport by Changing Feeder Bus Budget, 2020**



BRT = bus rapid transit, FB = feeder bus, km = kilometre, VND = Viet Nam dong.
Source: Study team.

5. Conclusion

In this chapter, feeder bus routes in Da Nang City were optimised for 2017, 2020, 2025 and 2030, and the results evaluated based on the new stated preference model assuming the BRT introduction. The results indicate that the introduction of the BRT increases public transport use, but the number of people who want to use the BRT far exceeds the planned BRT transport capacity. The following conclusions are drawn:

First, the transport capacity of the BRT should be enhanced at an early stage. The introduction of the articulated vehicle is a possible solution. However, as it is not sufficient, a shift to light rail transit or metro is required (Figure 4.16, left and middle). At present, metro is scheduled to be introduced in 2030, but its introduction should be brought forward.

Second, a feeder bus system is needed to promote the modal shift from motorcycles to public transport. The introduction of feeder buses can transform the BRT from a service that is only available to residents along the routes to one that is available in wider areas, contributing to an increase in the share of public transport. The introduction of the feeder bus system will promote the shift from motorcycles to public transport. But in the future, a rapid shift from motorcycles to cars is also expected along with an increase in income levels. If appropriate measures are not taken, the fuel consumption will increase together with the heavy traffic congestion. Increasing public transport users as much as possible before such a situation arises is a valuable choice for the future of Da Nang City.

Third, if the public transport network becomes well developed by introducing a feeder bus system and expanding BRT routes, the number of transferring passengers at the key stations is expected to increase sharply. Therefore, the transfer of passengers between different routes and different public transport means needs to be made smoother to enhance the attractiveness of the public transport. Measures such as the introduction of transfer systems, shown in Figure 4.16 (right), should be introduced at an early stage.

This study assumed a BRT system that uses non-articulated buses. Further research should evaluate the utility of introducing a BRT system with a higher transport capacity.

Figure 4.16: **Example of Measures to Improve Bus Rapid Transit Capacity.**

LRT = light rail transit.
Source: Study team.

Chapter 5

Conclusion

1. Energy and Traffic

In many countries, the transport sector is a mainstay of oil demand. To manage this demand, it is essential to improve energy efficiency in the transport sector. Various studies have been conducted for the purposes of improving automobile fuel economy and promoting the diffusion of alternative fuel vehicles. However, these measures are only part of solution for improving energy efficiency in the transport sector. The driving speed of automobiles has a bigger effect on fuel economy than is commonly realised, hence facilitating the smooth flow of car traffic is also a significant energy efficiency measure. Nevertheless, traffic congestion as an energy problem has received insufficient recognition and attention. This study contributes to the field through its focus on improving energy efficiency in the transport sector through reducing traffic congestion.

2. The Importance of Pre-emptive Measures

The study consists of a policy study and a quantitative case study targeting a specific city. The quantitative case study of Jakarta, Indonesia, during 2012 and 2013, showed that it is extremely difficult to solve severe traffic congestion. Larger investments are required and traffic infrastructure construction work itself worsens congestion.

Major findings from the Jakarta study are as follows:

- Oil consumption can be reduced by several percentage points by slightly reviewing the road shapes such as intersections and right- and left-turns.
- However, the effects of these improvements will cancelled out in several years by the sharply rise in automobile traffic.
- Accordingly, traffic infrastructure must be improved more drastically. Above all, it is imperative to install the MRT to encourage a modal shift.
- Making such large-scale infrastructure investments is challenging when traffic congestion is already severe.
- Accordingly, pre-emptive measures and actions from a long-term viewpoint are crucial for avoiding traffic congestion.

3. Case Study of Da Nang City

To explore this further, a case study was conducted on a mid-size city where a traffic congestion problem has not yet become obvious, but is expected to deteriorate in the future, resulting in a big energy loss unless proper measures are taken. Da Nang City, Viet Nam was chosen as a target, given the availability of data required for the analysis.

Da Nang City has decided to introduce a BRT system in order to respond to increasing traffic demand. The current mainstream traffic mode in Da Nang City is motorcycles, but as income levels rise, automobile ownership will increase and traffic congestion will become a serious problem with socioeconomic and energy efficiency implications. It is appropriate to develop the BRT to avoid this, but it will be meaningless unless citizens choose to take public transport instead of motorcycles and private cars. The administration must therefore focus on making public transport infrastructure, including the BRT, attractive to citizens. There are various ways to this. This study modelled the effects of developing feeder-line buses as a means of access to the BRT. Since the BRT operates on specific routes, it is only available to those living near the stations or when the stations are located near destinations such as workplaces and schools. Feeder-line buses enhance access between the residences, workplaces or schools, and stations. Their introduction is projected to increase utilisation of the BRT, thus reducing oil consumption.

The study revealed the following points:

- Development of the feeder bus system is effective in increasing the utilisation rate of the BRT.
- An interview survey conducted to learn about citizens' awareness of the BRT, there may be more BRT users than the planned transport capacity can accommodate.
- If the capacity of the public transport, including the BRT, is increased more than planned, more citizens will utilise it, further reducing economic and energy losses caused by traffic congestion.
- Conversely, if proper measures are not taken to improve the transport capacity of the BRT, convenience of the stations, access and egress, and other aspects, user convenience may be lost as public transport becomes congested, resulting in the failure of the public transport business.

The BRT project in Da Nang City is being implemented at a stage when traffic congestion is not yet a serious problem. It is therefore a good test case for the precautions recommended by this study. The model suggests that the convenience of Da Nang City's proposed BRT may be reduced by the higher-than-planned number of users. It is therefore desirable to steadily expand the capacity of public transport, adopting a long-term view. The project includes a railroad project, which is scheduled to start service in 2030 according to the city's current traffic plan. In light of the larger projected number of public transport users, one option would be to bring forward the development of the railroad.

Since demographics, industrial structure, and urban morphology change quickly in developing cities, the plan needs to be reviewed and revised in line with the changes. Da Nang City is not a special case. Now is the time to review its traffic plan in line with current circumstances.

4. Policy Guidance for Developing Cities

In the 2012 policy study[70], diversified traffic improvement policies were analysed and classified according to the keyword ASIF (Avoid, Shift, Improve, and Finance) (Table 5.1).

Table 5.1: Policy Options under the Avoid, Shift, Improve, Finance Framework

Key Word	Description	Measures
Avoid	Reduce travel demand by integrating land use planning and transport planning to create city clusters that require less mobility or reduce travel demand.	・Vehicle registration fees/tax ・Licence plate fee ・Mandatory vehicle insurance ・Road pricing ・Parking fee
Shift	Use the alternative mode of transport, such as mass rapid transit systems, to move away from passenger vehicles. Mass transit systems would include buses, railways, and subways, which would theoretically have lower energy–carbon dioxide intensities per passenger kilometre than passenger vehicles.	・Mass rapid transit systems ・Bus rapid transit systems ・Improving feeder bus services ・Improving multi-modal transfer through comprehensive tariff structure
Improve	Upgrade the overall efficiency of urban transport on vehicle efficiency through technological innovations, or policy measures to manage road traffic or use of information technology.	・Fuel economy improvement ・Alternative vehicles (electric, compressed natural gas, and fuel cell vehicles) ・Intelligent transport systems ・Incentives or regulation
Finance	Offer a monetary basis for developing and improving transport systems. Various taxes are available as the options, and the revenues could be reallocated to road improvement or public transport enhancement.	・Fuel tax ・Congestion pricing ・Environmental tax ・Vehicle registration tax ・Licence plate bidding ・Parking fees

Source: Study team.

From 2014 to 2015, the traffic policies including city planning were organised to improve energy efficiency in the transport sector (Table 5.2). Also discussed was how the public transport imperative for improving energy efficiency could be turned into a sustainable

[70] ERIA, Study on Energy Efficiency Improvement in the Transport Sector through Transport Improvement and Smart Community Development in the Urban Area, June 2013.

business. The basic points of contention in traffic planning for emerging Asian cities, such as Da Nang, were distilled to provide a guide so that policy planner could make traffic plans by themselves in future. The plan should take account of the circumstances peculiar to each city, but the factors related to energy efficiency can be generalised to some extent. Management of the public transport business is often a financial challenge for the municipality; therefore, it will be significant to present tips for improving management.

Table 5.2: A Recap of Considerations for Traffic Policy in Relation to Energy Efficiency

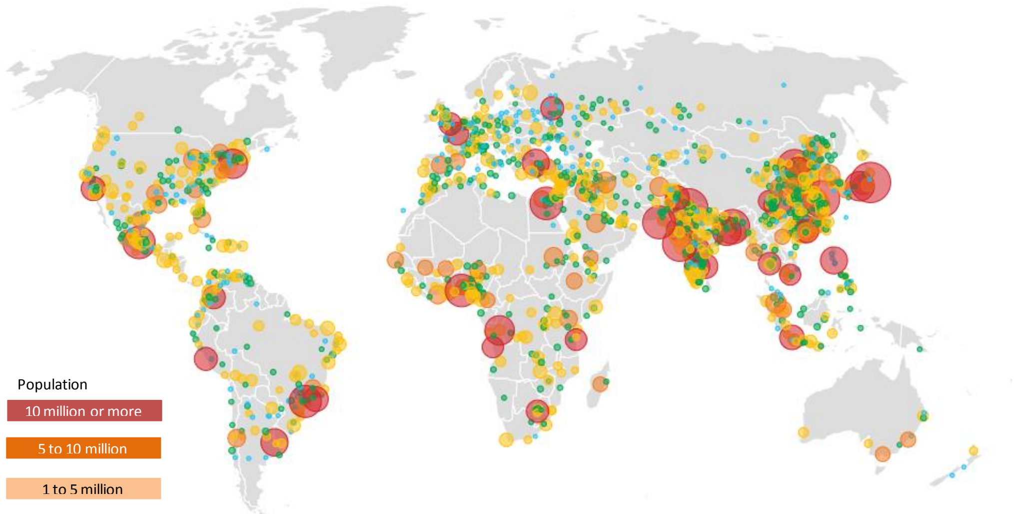
Item	Specific Improvement Points
Public transport design	
Rapidity	Equipment (trains, tracks, management systems); dedicated lanes; access; operation frequency; operation punctuality; transfers; ease of transit through stations
Safety	Vehicle (specifications, interior structure, impact resistance); maintenance; safety devices; dedicated lanes; driver skill; labour environment
Comfort	Interior temperature and humidity; drive safety; elimination of unpleasant factors (noise, odours, air contamination, crime)
Infrastructure investment	Recovery of the external economy (taxation and subsidies, real estate development)
Price and competition	Full cost pricing, franchising, yardstick, price cap, congestion charges, peak load pricing
Public private cooperation	Public–private partnership, private finance initiative, concession, management commission, build–operate–transfer, etc.
City policy	
Design	Urban planning (land zoning, height limits, floor area ratio, building to land ratio); high-rise buildings; preparing spacious and comfortable walking and bicycling routes; ample space between buildings; construction of parks and libraries; securing population fluidity
Tax policy	Handling of commuting costs and housing subsidies, residency tax, property tax
Infrastructure	Pricing that reflects population density, withdrawal from inefficient areas
Transport policy	
Taxation	Types: Gasoline tax, automobile acquisition tax, automobile tariffs, licensing fees Points: Taxation effects, speed of taxation effects, application of tax revenue, taxation timing
Regulations	Clarify purpose and method, side effects, the problem of effectiveness and cost
Subsidies	Effectiveness of subsidies, the problem of dependency on subsidies
Combination	The three patterns of policy effects, the principle of problem simplification
Other	Fairness, altering roads, inertia, technological innovations, citizen's viewpoint

Source: Study team.

5. Policy Recommendation

As repeatedly mentioned, it is most important to steadily take the necessary pre-emptive measures to avoid serious car traffic congestion in the developing Asian countries where urbanisation is expanding quickly. In some big cities, including the capitals of the ASEAN member countries, chronic traffic congestion is already leading to wasteful consumption of oil products. Many more huge cities will emerge in these countries in the future, as shown in Figure 5.1, and it is vital that the same failures are not duplicated.

Figure 5.1: Outlook for Urbanisation in 2030



Source: Economist, Bright lights, big cities - Urbanisation and the rise of the megacity, 4 Feb 4 2015.

The key points for policy making and the specific examples of policies are as described in Chapter 2 and the past study reports. A more fundamental issue is how to handle an energy policy and a traffic policy in an integrated manner. In many countries, energy administration and traffic administration belong to different ministries, and there is not always close communication and coordination between the parties. Accordingly, the first step is for an energy policy maker to recognise the traffic policy as part of the energy policy and vice versa. It is preferable to jointly make a policy package that manages the energy and traffic aspects of the transport sector in a consistent manner.

In reality, the core of the policy package is related to the usage of land, the urban structure, and the means of transport, such as roads and public transport. This may lead to a greater role for the policy maker in the traffic field. What is important is to include as part of policy-making procedures a strict scrutiny and review of the energy aspects of various draft traffic policies, and to make the energy policy maker a partner in this process. Currently, such a process is missing or insufficient.