Regional Development Studies, Vol.4, pp.65-85, 1998.

Examining the Effects of a Mass Rapid Transit System on Easing Traffic Congestion in Auto-dependent Bangkok

Yoshitsugu Hayashi
Krit Anurakamonkul*
Takaaki Okuda
Omar Osman
Hideki Nakamura
Nagoya University

Abstract. This article examines common characteristics of urban congestion and evaluates the effectiveness of introducing a mass rapid transit (MRT) system to alleviate traffic congestion, using Bangkok as a case study. It is observed that the diversity and capacity of transport infrastructure play a crucial role in determining congestion levels, once a city or region has experienced rapid economic growth, urbanization, and motorization. The study has an analytical framework for travel-choice behaviour based on stated-preference (SP) models to assess long-term MRT contributions to congestion relief under alternative policy measures. Work trips and the entire network of the planned MRT system are defined as the scope of the study. Certain empirical results suggest that initial diverted-demand from road-based facilities to MRT services will mainly take place at the expense of reduced bus modal share. Since bus users are major commuters who spend considerable time traveling, this brings about a larger decrease in average travel time per trip while providing a minimal decrease in average road speeds. Adjustment of MRT fares also seems inelastic to its patrons. However, preferences on car use can be effectively influenced when incorporating MRT with broader access (feeder) services on an area-wide basis. Realization of this potential in the Bangkok case may be regarded as an ideal strategy for other rapidly-growing developing cities in which similar hypercongestion problems are already appearing.

KEYWORDS: Urban Traffic: Transport Infrastructure: Urban Transport: Forecasts: Thailand.

INTRODUCTION

Mass rapid transit (MRT) or rail transport systems have been regarded as potential means of tackling urban traffic congestion, reducing road accidents, and alleviating environmental problems in many developing cities. They are indispensable for reviving urban economic activities in both developed and developing countries and in those mega-cities currently facing either massive population problems, relatively high per-capita income levels, or a combination of both, and are thereby forced into a dependence on MRT systems. However, this is not yet the case for Bangkok. As far as city population and income levels are concerned, Bangkok is the only mega-city without a MRT system (either subway or elevated rail transit). It is therefore rapidly becoming an auto-dependent city. Another crucial distinction between mega-cities in the developed countries and those in the third world is that cities in the developing countries are likely to introduce MRT systems only after being faced with rapid motorization and rampant urbanization, while those in cities of the developed countries have been established as an integral component of the urbanization process or even in advance of it, thereby shaping and controlling most spatial development along urban rail transit corridors. Under these contrasting circumstances, there is the controversial issue of whether or to what extent a planned MRT system can be developed to successfully mitigate urban congestion, particularly for heavily auto-dependent cities such as Bangkok.

Since Bangkok's population has no experience in using a MRT system, there is no information available on actual travel behaviour. In other words, it is essential to devise an analytical tool to act as a mode-choice model to evaluate the impact of any future MRT system. This is particularly crucial to Bangkok — where the existing conventional railway (with a very low level of service) remains far beyond the reach and recognition of most local commuters. The study uses stated-preference (SP) data to address the effectiveness of a future MRT system and to examine its applicability within the framework of diverse policies. Unlike other SP work found in previous research, the underlying notion here is to investigate the impact of a MRT system on future travel demand and congestion relief when considering the entire MRT network. For planning purposes, this will enable decisive elements that affect policy measures to be evaluated more precisely because travel choices are made under virtually real conditions of travel behaviour. It will also provide a better understanding of the trade-off between the long-term contribution of a MRT system and its huge capital investment requirements.

TRAFFIC CONGESTION IN BANGKOK: A PERSPECTIVE

Recent evidence has shown that urban congestion is a common phenomenon occurring in many large cities of the developing world. Typically, these cities experience rapid economic development, a high concentration of population, and increasingly dispersed urban sprawl. As the regional economy continues to grow and public land availability becomes scarce, it is impracticable and costly to constantly provide road-based infrastructure to keep pace with rapid population growth and journey demand. It is therefore difficult to provide adequate transport modes to accommodate the diversity of travel demands in peripheral areas, and thus traffic congestion is the result. Since transport infrastructure represents, if not the engine, then the wheels of economic activity for regions undergoing urbanization, a selective approach based on supply-side economics should be established to determine which kind(s) of urban transport modes are more efficient and reliable than those currently available.

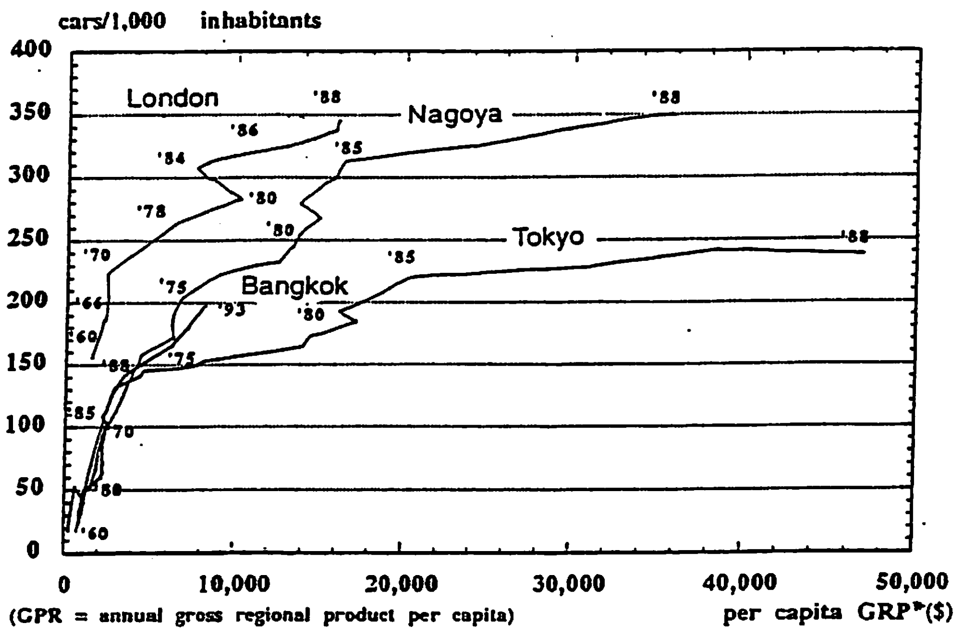
Urban Transport Infrastructure and Spatial Development

Geographically, suburban sprawl in Bangkok is taking place along major radial arteries between and behind which are considerable parcels of undeveloped land. This pattern of spatial development is not only inefficient in its land use but is also uneconomic in terms of the poorly coordinated provision and utilization of land transport infrastructure. It is common for developing cities in Southeast Asia that undergo rapid spatial development for human settlements to develop in areas far from the city centres, owing to high urban land prices resulting from the intense demand in the city area.[1/] Likewise, basically concentrated in the central area of Bangkok, the existing uneven and centralized network of main roads suffers from a serious lack of feeder roads essential for linking many developing areas located behind the major roads. Nevertheless, major travel choices in Bangkok depend solely upon the road transport system (i.e., car, bus, and motorcycle). Other minor vehicular modes such as railway and bicycles are seriously neglected. While almost 40 per cent of total daily person trips are facilitated by motor cars, less than 1 per cent of person trips are through conventional railways, owing to the extremely limited rail network and its low serviceability. It is obvious why the use of private transport in Bangkok (which occupies the majority of road space) accounts for ten and five times more trips than in Singapore and Kuala Lumpur, respectively.[2/]

Imbalance between Travel Demand and Infrastructure Supply

After exploiting over three decades of rapid economic growth concentrated in and around Bangkok, the capital is now suffering from severe traffic-related problems which initially arose from a deficiency in coordinating between transport provision and spatial development planning and was later aggravated by rapid motorization — particularly from private-car use. Comparing the intensity of car use in developing and developed cities, figure 1 indicates the steep income elasticity of demand for car ownership, particularly in the initial stage of rising incomes. In

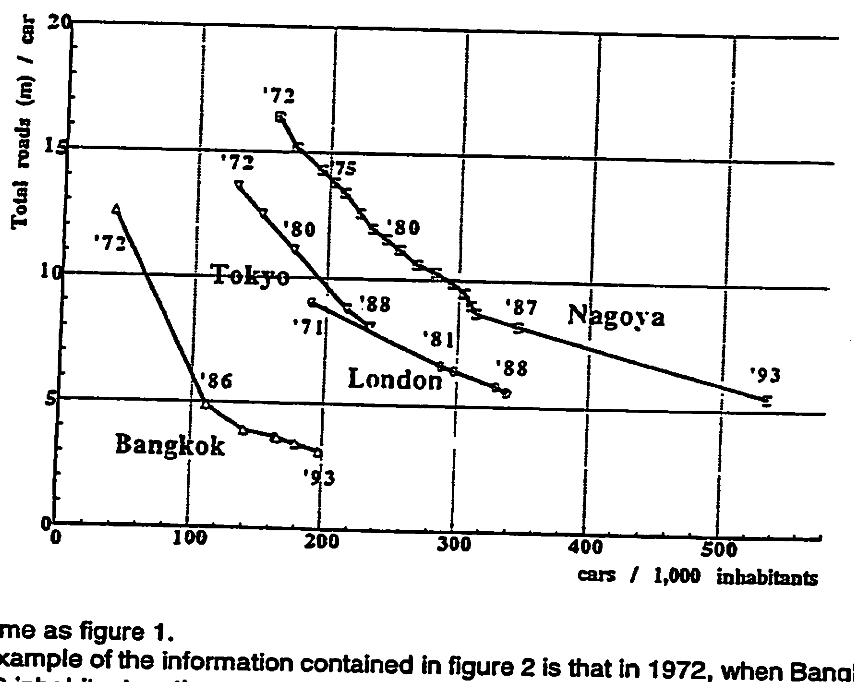
Figure 1. Relationship between Motorization and Income Levels



Source: Yoshitsugu Hayashi *et al.*, "Urbanization, Motorization and the Environmental Nexus — An International Comparative Study of London, Tokyo, Nagoya, and Bangkok" (Memoirs of the School of Engineering, Nagoya University, vol. 46) (Nagoya, 1994).
Note: *GRP = Gross regional product.

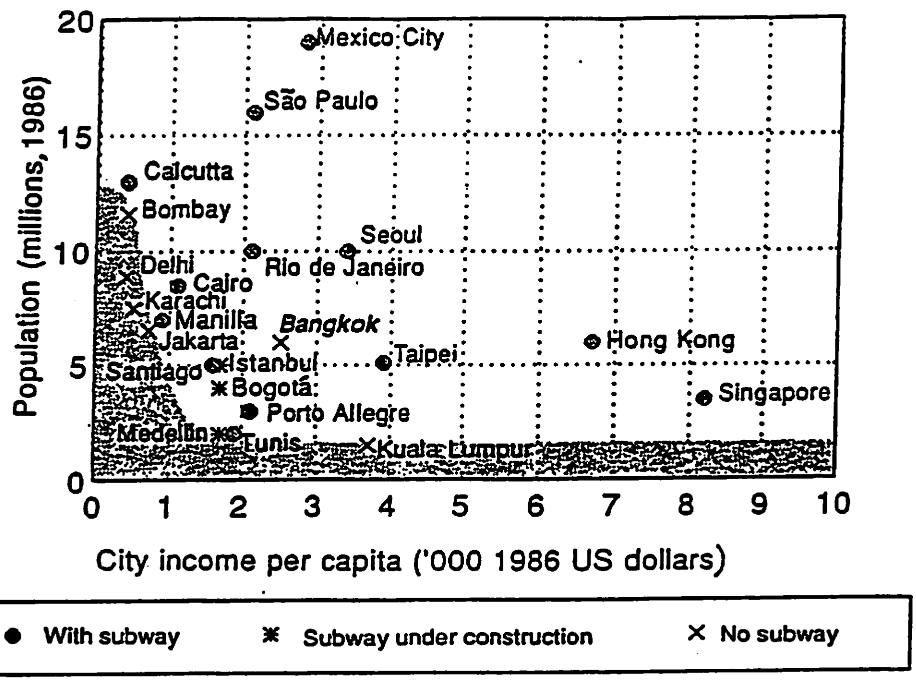
contrast, car ownership in certain developed metropolises such as Tokyo seems to have reached a plateau, even though income levels keep rising. This situation results primarily from the extensive rail transit facilities associated with their high levels of service. Since there is virtually no rail transit currently functioning efficiently in Bangkok, car ownership tends to increase at the same or even at higher rates without substantial provision of transport infrastructure, especially a MRT system. On the supply side, figure 2 indicates the crucial relationship between motorization (demand) and road (supply) length per car. Though car ownership and income levels in Bangkok in 1993 were almost equivalent to those in other developed cities (i.e., London, Tokyo, and Nagoya) in the 1970s, the provision of transport infrastructure in terms of road length per car in Bangkok was merely one-fourth to one-third of that in those cities for the same period. The traffic situation, therefore, was much worse when considered together with the absence of a MRT system in Bangkok. As shown outside the shaded area in figure 3, most developing megacities approaching either high per-capita income levels or certain large population sizes are obliged to rely on their MRT systems. It is to be noted that Bangkok is the only city in this category that has no MRT system in operation or even under construction during this period.

Figure 2. Motorization Levels Versus Road Infrastructure Supply



Source: Same as figure 1.
Note: An example of the information contained in figure 2 is that in 1972, when Bangkok's car per 1,000 inhabitants ratio was around thirty cars per 1,000 people, the density of cars per m of paved road was around 12.5 m per car. In the twenty-one years to 1993, this had worsened to 200 cars per 1,000 people with an average road space of only 3 m per car.

Figure 3. Availability of MRT Service (Subway or Elevated Rail) in Selected Cities of Developing Countries

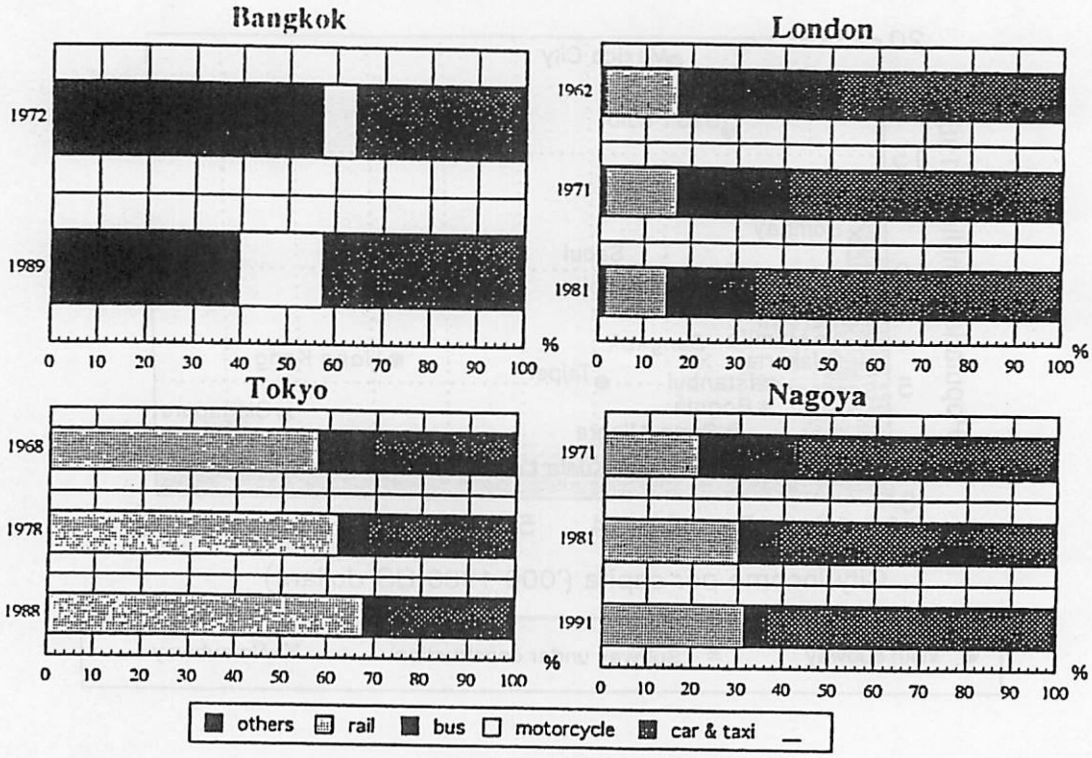


Source: Modified from R. Fouracre, J. Allport, and M. Thomson, "The Performance and Impact of Rail Mass Transit in Developing Countries" (TRRL Research Report; no. 278) (Paris, 1990).

Current Modal Share and Traffic Congestion

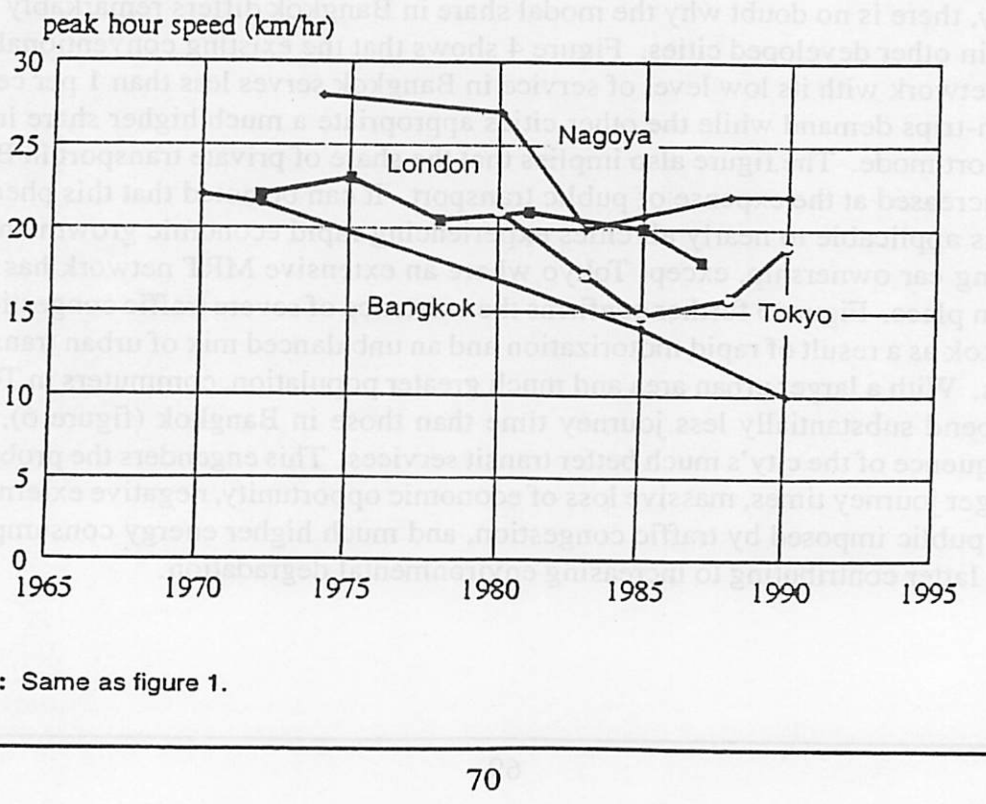
Taking into account the large discrepancy between urban transport demand and supply, there is no doubt why the modal share in Bangkok differs remarkably from those in other developed cities. Figure 4 shows that the existing conventional railway network with its low level of service in Bangkok serves less than 1 per cent of person-trips demand while the other cities appropriate a much higher share in this transport mode. The figure also implies that the share of private transport in Bangkok increased at the expense of public transport. It can be noted that this phenomenon is applicable to nearly all cities experiencing rapid economic growth and increasing car ownership, except Tokyo where an extensive MRT network has long been in place. Figure 5 further confirms the existence of severe traffic congestion in Bangkok as a result of rapid motorization and an unbalanced mix of urban transport modes. With a larger urban area and much greater population, commuters in Tokyo still spend substantially less journey time than those in Bangkok (figure 6), as a consequence of the city's much better transit services. This engenders the problems of longer journey times, massive loss of economic opportunity, negative externality to the public imposed by traffic congestion, and much higher energy consumption — the latter contributing to increasing environmental degradation.

Figure 4. Time-Serial Change of Modal Shares (by person trips)



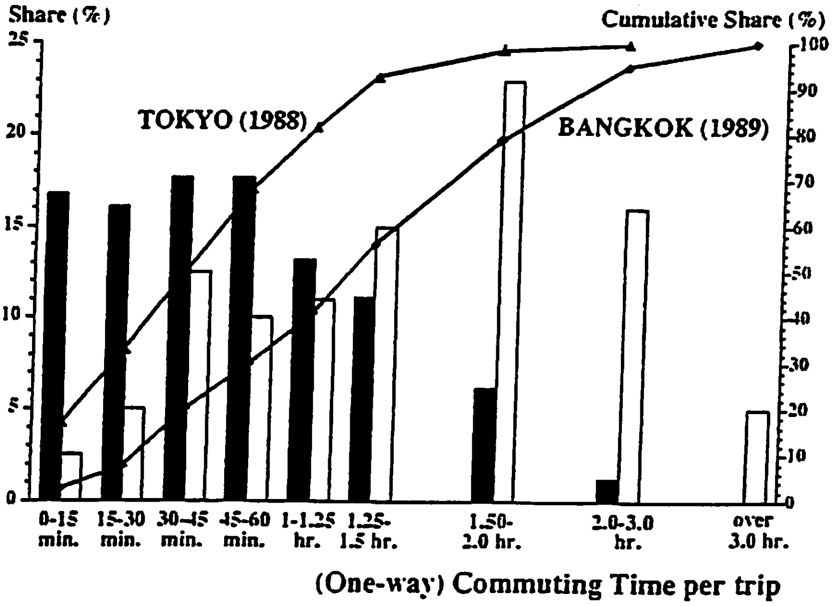
Source: Same as figure 1.

Figure 5. Change in Average Peak-Hour Speeds in Different Cities



Source: Same as figure 1.

Figure 6. Comparative Distribution of Commuting Times in Tokyo and Bangkok



Source: Yoshitsugu Hayashi and Krit Anurakamonkul, "Effect of Transport Attributes on Urban Congestion and the Environment: The Case of Bangkok" in *Proceedings of the Twenty-Fourth European Transport Forum (PTRC)* (London, 1996).

MODE-CHOICE ANALYSIS FOR DEMAND FORECASTING

Use of Stated-Peference Data

SP-data techniques are becoming increasingly popular in transport planning and management, both as tools to determine the monetary values that modal users and nonusers place on the transport system attributes as well as for demand forecasting. The main purpose of SP research is to gain an understanding of how people make their transport choices. The technique is particularly useful in assessing travel demand and to identifying the sensitivity of the SP approach to different forms of policy instruments when potential usage of a newly-introduced transport service is being examined.

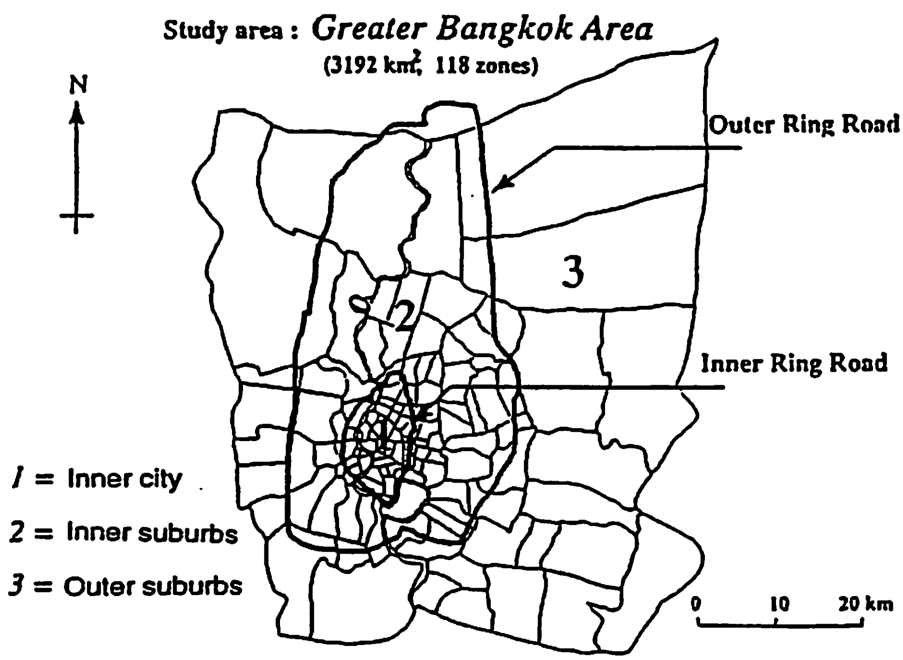
Validity of the Stated-Preference Approach to the Study

As mentioned earlier, Bangkok residents have never experienced a MRT system, meaning that actual information on choice-making behaviour cannot be obtained. To overcome this obstacle, estimation of demand change in future travel behaviour may be analysed using SP or revealed-preference (RP) approaches. Though constructed by a nested-logit model structure to mitigate relevance or similarity of modal attributes as verified in the classical case of "red bus and blue bus,"[3] the predicted RP results seemed rather overestimated as noted in recent studies.[4] The underlying assumptions of the nested RP logit models still consider MRT attributes simply as just another type of public transport mode, like bus transport, for instance. In other words, these RP model settings do not explicitly reflect the distinction of modal characteristics and functions between MRT and other transport modes. On the contrary, SP models with multinomial settings are more applicable in that they can elicit preferences with respect to a totally new (or nonexisting) MRT transport option and can distinguish the associated MRT attributes objectively from other public transport alternatives. Additionally, a SP choice set can be prespecified and its range of mode attributes can be easily extended to incorporate qualitative components of considerable research interest.

Study Area and Scope of Analysis

The study area is the Greater Bangkok Area (GBA) which comprises Bangkok and three surrounding provinces with a total population of 8.1 million and an area of 3,192 km² (see figure 7). In an attempt to accommodate the rapid growth of travel demand and to reduce car use, the Government of Thailand is planning to establish an initial MRT network of 175 km by the year 2010. Since over 90 per cent of the total daily travel demand (by person trips) in the GBA take place within the outer ring-road boundary, the primary MRT network configuration is designed to improve urban mobility inside the outer ring-road area. Demand forecasts are computed by using the estimated volume of trip generation from previous research along with the potential transport network planned to be available by the year 2010.

Figure 7. Control Territory and Zoning Configuration of the Study Area



Source: See International Bank for Reconstruction and Development (IBRD), "The Seventh Plan Urban and Regional Transport Study (SPURT)" (World Bank Study for the National Economic and Social Development Board (NESDB) of Thailand) (Bangkok, 1992). (Modified for presentation here)

Commuting trips are the subject for this study because they account for a high proportion of both total trip volume and overall trip distances. In fact, it is true for most cities that MRT systems deserve the largest component of urban mobility during peak-hour periods. For reasons of simplicity as well as data availability, the current study considers only the diversion impact of introducing MRT services based on car and bus shares since these are the two dominant motorized vehicular modes which occupy major road space, thereby constituting the overwhelming reason for the worsening urban congestion.

Methodology

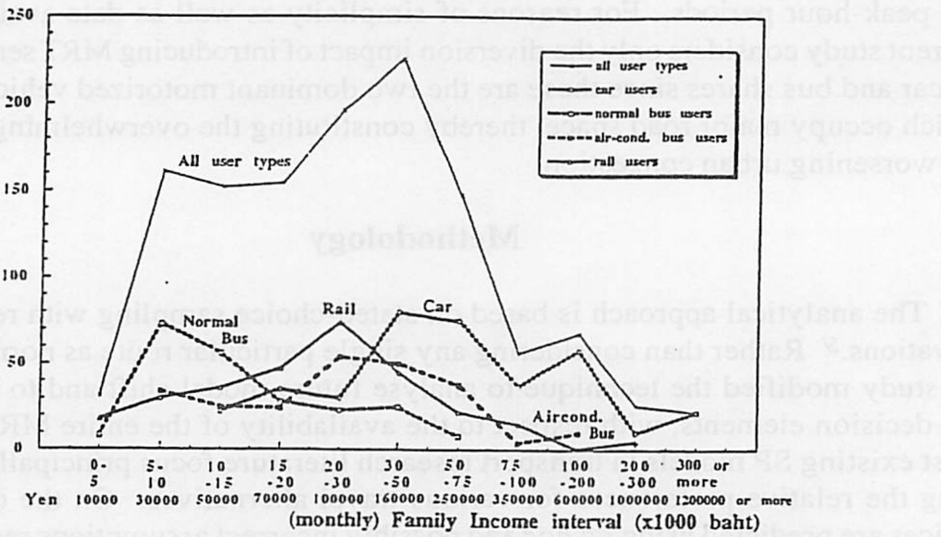
The analytical approach is based on stated-choice sampling with repeated observations.[5/] Rather than considering any single particular route as normally done, the study modified the technique to analyse future modal shift and to distinguish key decision elements, with respect to the availability of the entire MRT network. Most existing SP models in transport research literature focus principally on measuring the relative preferences for various travel alternatives. On the other hand, choices are predicted using *ad hoc* and possibly incorrect assumptions regarding the relationship between preference structure and choice behaviour.[6/] In contrast, stated-choice models such as the one under study are directly derived from choice sets observed under hypothetical treatments (defined scenarios). Choices, rather than preferences, can be directly measured in the controlled experiments. Therefore, the analyst can observe straightforward choices from data and does not have to make *ad hoc* assumptions regarding the relationship between preferences and overt choice behaviour. This approach constitutes a powerful tool to simultaneously examine the assumed choice model and specification of the implied utility functions.

Sampling Procedure and Sample Characteristics

The survey was conducted in Bangkok in April 1996 and consisted of 255 samples. The samples represented current vehicular users of major modes residing in diverse locations within the study area. Individuals were randomly selected and presented with a series of different hypothetical travel choice sets. They were asked to express their choices subject to the contrasting travel attributes given in each set of travel alternatives. Figure 8 illustrates a reasonable distribution of monthly household incomes by user groups. Car and bus modes are generally used by high- and low-income groups, respectively. Interestingly, the current users of the conventional railway mode (not MRT) are from a broader base covering all income groups. In other words, the rail transport system has the potential to serve both high- and low-income groups once urban congestion justifies it and/or a satisfactory level of service quality is provided. It is also shown in figure 9 that there are considerable numbers of rail users and air-conditioned bus users who own cars but are still willing to use public transport provided that a relatively efficient level of service is available.

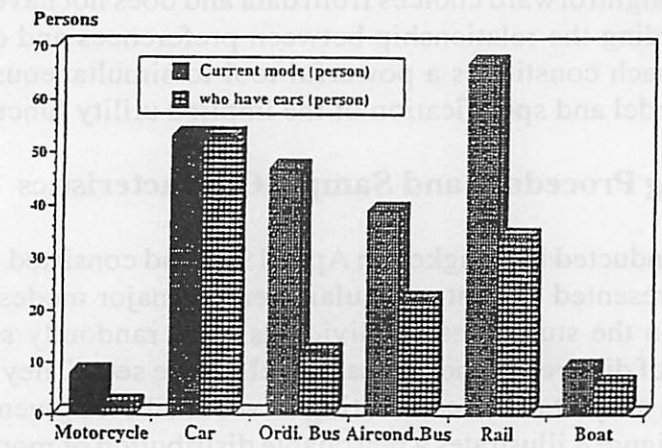
Regional Development Studies, Vol.4, pp.65-85, 1998.

Figure 8. Distribution of Household Income Levels by Modal-User Type



Source: Developed by the authors from SP data collected for the study.

Figure 9. Car Availability of Samples Classified by Modal-User Type



Source: Same as figure 8.

Model Structure and Specification

Multinomial logit (MNL) model structures are employed in the study based on the assumption that individuals can perceive and determine the real attributes of MRT mode choice from among other attributes. After scrutinizing the possible relationships between various components of the choice function, the model is constructed subject to several significant attributes such as travel time, travel cost, monthly household income, and the level of household car ownership. By considering the functional form on the systematic components of utility function, it is convenient to restrict model attributes to the class of linear-in-parameters functions. Therefore, model parameters are later calibrated as a linear attribute functional setting, assuming the uniform scale parameter is equal to one.

To ensure heterogeneity of population in the transport market and applicability of the models to the entire study area, multinomial logit models are separately calibrated for the main types of current transport users in Bangkok (i.e., car users, ordinary bus users, and air-conditioned bus users). Travel demand was disaggregated at the individual level to identify the likely modal shifts from each user type, and later aggregated to estimate the diverted demand for any travel modes available in the future, especially the potential users of a MRT system.

CALIBRATION OF MODE-CHOICE MODELS

The estimated origin and destination (OD) trip matrices (after trip generation and trip distribution) in the year 2010, from the previous studies[2] which were subject to "without MRT" assumption, were disaggregated and grouped by zone, using the car ownership model developed in the study. Each group of users was then split into different travel choices by means of separate corresponding SP mode-choice models. The selected mode-choice models by user types are shown in table 1.

All models were calibrated using the utility of car choice as a relative reference. By examining the constant parameters which account for all explanatory variables not included in the models, it is rational that car users consider the car mode as the best option while the MRT option is considered inferior to car use with bus option rated as the worst. In contrast, both ordinary and air-conditioned bus users regard MRT as being superior to car use while conceiving the bus as the worst travel alternative. The discrepancy may stem from the diverse socioeconomic backgrounds and car availability levels among these user types. The minus sign of all attribute parameters is also rationally coherent to their corresponding utility functions.

TABLE 1. PARAMETER ESTIMATION OF SELECTED MODE-CHOICE MODELS CLASSIFIED BY USER TYPE

Attributes \ User Types	Ordinary Bus Users	Air-cond. Bus Users	Car Users
MRT mode constant	**+1.127** (+3.0)	+0.171 (+1.9)	**-0.662** (-4.0)
Bus mode constant	**-1.423** (-2.2)	**-0.408** (-2.7)	**-3.036** (-5.3)
Travel time (minutes)	-0.011 (-1.7)	**-0.029** (-2.1)	**-0.024** (-2.0)
Travel cost per monthly household income	**-751.635** (-3.9)	**-482.980** (-2.4)	**-469.467** (-2.1)
ρ^2 (Likelihood ratio index)	0.33	0.32	0.41
No. of SP observations	216	232	374
Percentage of correct predictions (Hit ratio)	72	69	67

Note: t-statistics shown in parentheses; and calibrated parameters with significant t-statistic values are bold-faced.

Validation of Market Segmentation

To achieve more precise and reliable estimation results, the study employs a stratification approach to explore possible variations of individual tastes for travel choice behaviour. The notion is to systematically identify an appropriate set of socioeconomic subgroups of all trip makers who react differently when choosing travel modes. These variations stem from diverse perceptions, attitudes, social status, and other socioeconomic factors. Normally, individual variations may be classified by user group or household-income class. Owing to the sampling technique with repeated observations, the random error component or disturbance term in MNL utility function is not theoretically independent as assumed in the logit properties. For instance, observations from any similar sample will also have the same household income value. Therefore, it was decided not to adopt income class as an indicator to segment the population market.

The validity of market heterogeneity can be examined by using the analysis of variance (ANOVA) statistical method to inspect the equality of any particular mean of travel choice selection among subgroups. By definition, the null hypothesis (H_0) is one which indicates that there is no difference between the mean values (μ_i) of travel-choice selection. If H_0 is rejected, it implies that there exists a significant discrimination in selecting travel modes between any two subgroups of population in the market, thus market segmentation should be implemented. Otherwise, the market segmentation is not necessary and estimates can be simply analysed from a single generalized model for the whole population.

Since the change in MRT patronage is one of the prime interests in this study, H_0 among subgroups in this regard represents the equality of average choice probability (mean value) of choosing a MRT mode between each pair of user subgroups

$$H_0 : \mu_1 = \mu_2$$

where μ_1 represents the mean value of individual choice probabilities (to choose a MRT mode) for a specific user subgroup, e.g., μ_1 could represent the average propensity for a car-user subgroup to use a MRT system.

As a result of the F ratio test in table 2, there exists a significant difference in the mean choice probability (to choose a MRT alternative mode) among each group of users. Hence, the presumable segmentation approach by user types to account for population heterogeneity in the transport market is statistically acceptable. In other words, prediction performance from these separately calibrated models in terms of diverse user types becomes more reliable.

RESULTS

Various outcomes are analysed to examine the contribution of MRT with respect to areas of interest. Two scenarios — one with and the other without MRT — are used as a comparative basis to determine the effectiveness and decisive effect of the MRT system on the traffic situation. Since the SP mode-choice models generally incorporate many attributes, as described in the previous section, the empirical results imply that travel time, travel cost, and household-income levels play an interactive trade-off role in the decision-making process of most commuters.

Regional Development Studies, Vol.4, pp.65-85, 1998.

TABLE 2. *F* RATIO STATISTIC TO TEST DIFFERENCES IN MEAN VALUES AMONG USER TYPES

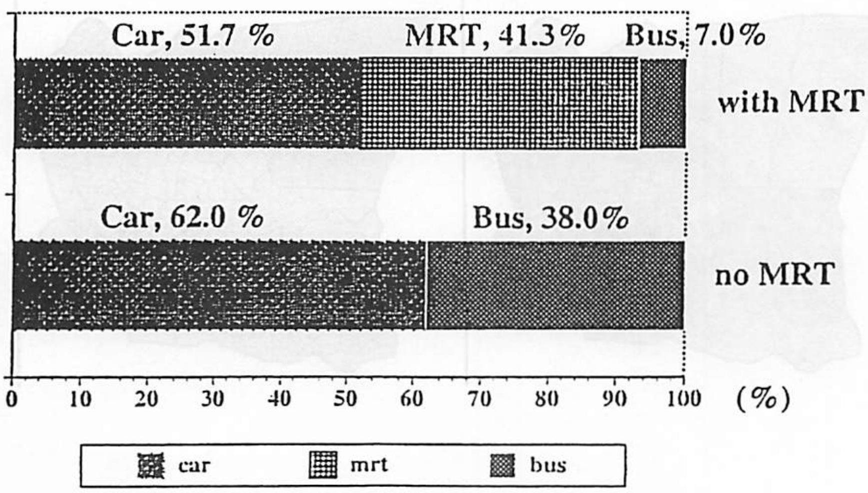
Mode Users	Observation Size	*F* ratio Statistic	$F\alpha$ (α=0.01)
Car users vs. ordinary bus users	437	1745*	6.63
Car users vs. air-cond. bus users	516	917*	6.62
Ordinary bus users vs. air-cond. bus users	205	296*	6.62

Note: Observation size calculated from car users and bus users with car availability; and *statistically significant.

Change in Modal Share: Modal Shift to Mass Rapid Transit

Figure 10 shows the preponderance of car and bus users in the year 2010, comparing the respective users in cases of MRT availability or nonavailability. The modal share of cars, in the absence of a MRT system, far outweighs that of the bus owing to auto-dependency and the inadequate road infrastructure. On the other hand, users of a MRT system will be mostly diverted from the modal share of bus users due to the low quality of bus services. Accordingly, figure 11 demonstrates the future distribution of estimated modal shares by zone. As expected, the MRT modal share is high in the central area of Bangkok where an extensive MRT network with many stations is to be provided. Nevertheless, the MRT system's contribution in some outer zones is more limited because of the low-access service and the relatively high-access costs. Moreover, so as not to overstate the predicted demand for a MRT system, the study uses relatively low cost and time estimates for

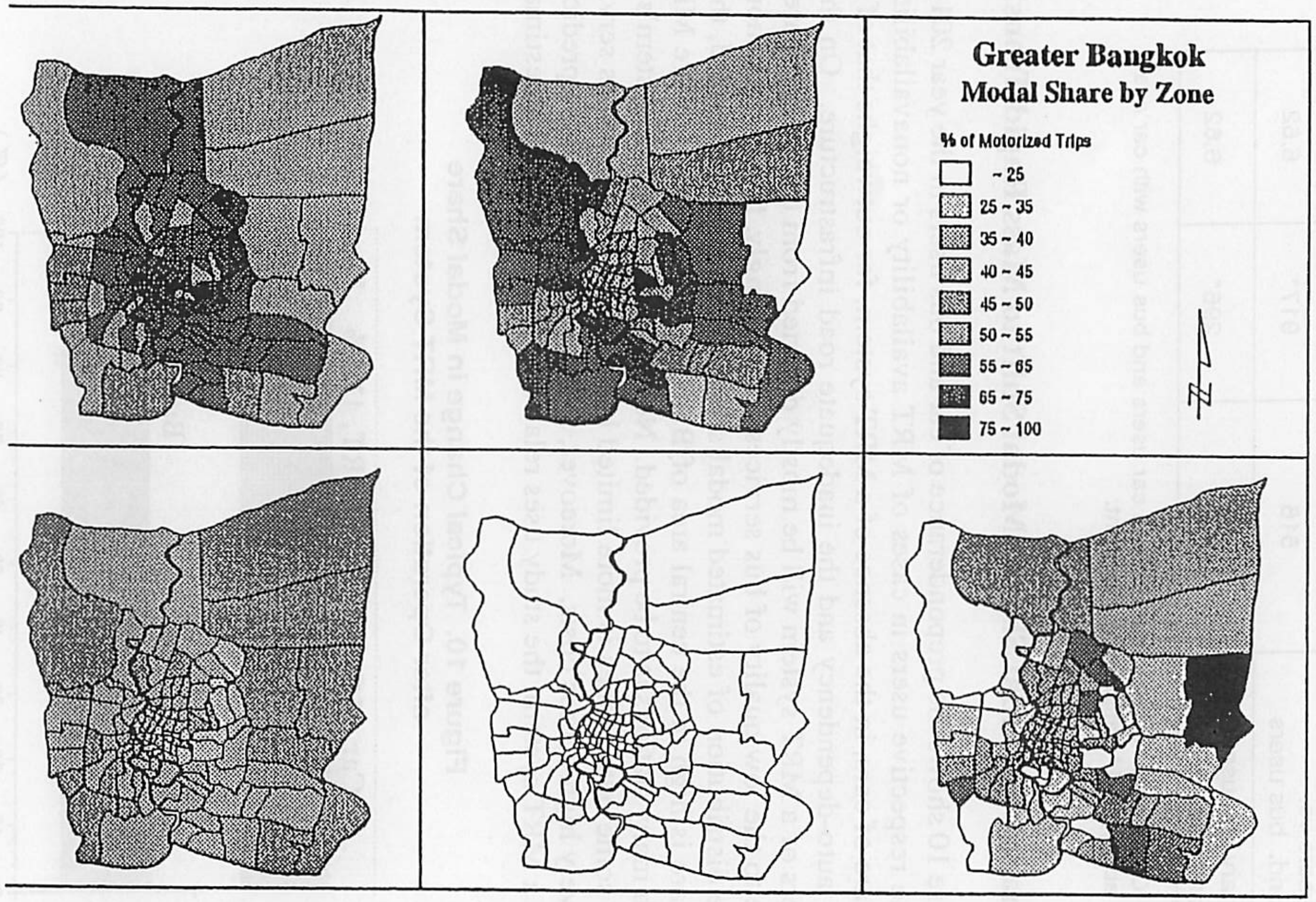
Figure 10. Typical Change in Modal Share after Operation of the MRT System



Source: Authors' analysis from mode-choice models in the study.

Regional Development Studies, Vol.4, pp.65-85, 1998.

Figure 11. Change in Modal Shares by Zone after Operation of the MRT System



Source: Analysed by authors and displayed using a geographical information system (GIS).

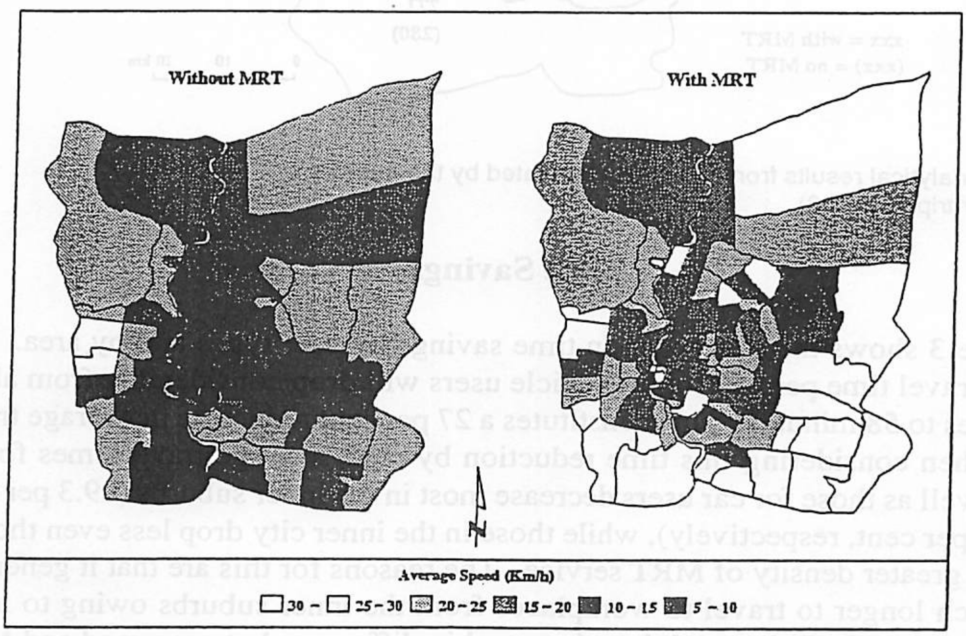
Regional Development Studies, Vol.4, pp.65-85, 1998.

existing bus and car modes. Though the MRT share seems high (about 40 per cent) for commuting demand, this estimate is consistent with MRT contributions in other mega-cities. In Bangkok, where particularly heavy congestion exists, it is likely that a larger share of work trips can be diverted to MRT. In general, however, any increase in the use of a future MRT mode will occur mainly at the expense of bus trips since there is a much larger discrepancy in travel time and cost between the MRT and buses than between the MRT and cars, i.e., 75 per cent of diverted demand to MRT comes from previous bus users, and the rest (25 per cent) is from car users.

Change in Travel Speed, Time, and Congestion Relief

In large and rapidly-growing developing cities, the burden of vehicle congestion already gives rise to considerable economic and environmental costs (externalities). It has been estimated that if reduced traffic congestion permitted a 5 per cent increase in peak-hour vehicle speeds, the value of travel time saved would amount to more than US$400 million annually.[8/] Figure 12 illustrates the distribution of average travel speed for each zone. It was equated using travel speeds for all trips generated from any particular zone to the others. When introducing a MRT system, the central city will gain the most benefit from congestion relief, i.e., an increase in average road travel speed, because most MRT stations are located within this area. Meanwhile, the proportion of trips taking place exclusively in the city centre is not the biggest. If all trips originating from one specific area to every other area are defined as the trips for that area, it becomes readily apparent that the inner city areas will gain most from any form of congestion relief. In short, the total average speed for the entire study area can be increased by 16.4 per cent and the overall average travel time can be reduced by 27 per cent.

Figure 12. Average Road Travel Speed of Trips Generated from Each Zone

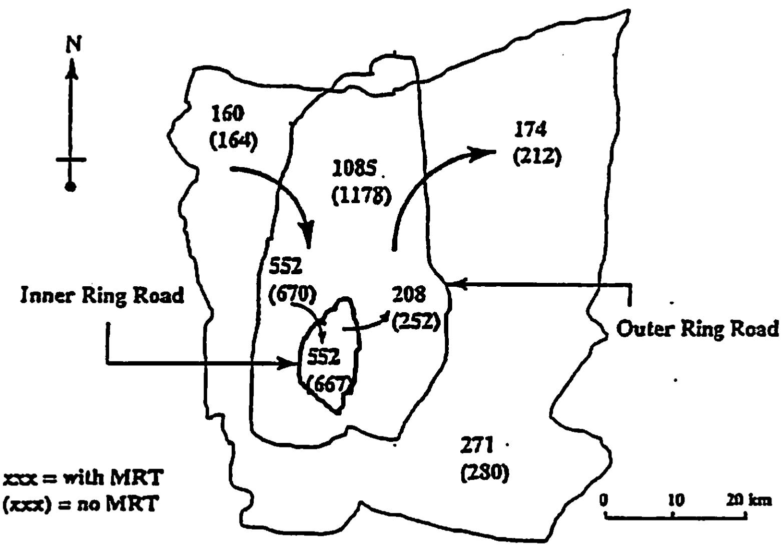


Source: Authors' analysis from models in this study, displayed using a GIS.

Traffic Flows Across the Controlled Areas (Boundaries)

By using inner and outer ring roads as boundary lines for traffic volume control, figure 13 illustrates the aggregated inflow and outflow trips across the boundaries. It is to be noted that over 85 per cent of total work trips are conveyed within the outer ring-road boundary. Furthermore, the trips restricted to the inner suburbs (the area located between the outer and the inner ring roads) account for 57 per cent of total work trips, which is much higher than trips occurring in the inner city (within the inner ring road). Unfortunately, both the road network and the future MRT system are concentrated in the inner city, thus providing higher levels of road and MRT services to the same area. As a result of this unbalanced MRT network configuration, there will be a greater reduction of car trips in the inner city (17 per cent), but a smaller reduction (9 per cent) in the much larger area within the outer ring-road boundary.

Figure 13. Inflow and Outflow of Aggregated Traffic by Area*



Source: Analytical results from this study tabulated by the authors.
Note: *Car trips (x1,000).

Time Savings

Table 3 shows the difference in time savings by user types and by area. The average travel time per trip for all vehicle users will drop considerably from about 80 minutes to 58 minutes. This constitutes a 27 per cent reduction in average travel time. When considering this time reduction by area, average travel times for all users as well as those for car users decrease most in the inner suburbs (29.3 per cent and 18.1 per cent, respectively), while those in the inner city drop less even though there is a greater density of MRT service. The reasons for this are that it generally takes much longer to travel to workplaces from the inner suburbs owing to inadequate transport facilities, and there is not a big difference between road and MRT facilities in the inner city. The larger percentage drop in travel time for all users

TABLE 3. AVERAGE TRAVEL TIME BY USER TYPES AND BY CONTROLLED AREA

(in minutes)

Area	Mode Users in Case of No MRT			Mode Users in Case of MRT Construction			
	Car	Bus	All	Car	Bus	MRT	All
Inner city	53.4	71.7	60.6	45.1	55.8	44.6	45.7
Inner suburbs	73.6	96.4	82.8	60.3	74.4	50.4	58.5
Outer suburbs	87.1	106.0	95.5	77.4	87.4	64.6	73.0
Whole area	70.4	91.9	79.2	60.0	72.7	49.1	57.6

compared to car users alone results from the fact that 75 per cent of estimated MRT use is diverted from previous bus users who account for longer travel times and suffer most from the severely congested traffic conditions.

Limitations of the Findings

Though the study results provide useful information for transport planners, care should be taken in considering their applicability. Two areas of caution related to demand forecasting need to be emphasized. First, with respect to the SP model, a period of adaptation will ensue following inauguration of MRT services during which citizens will gradually become used to the facilities and appreciate the attributes and functions. Threshold values might be incorporated as significant parts in the choice preference or utility functions of travel modes. This issue can be tackled later after it becomes possible to gather actual information from authentic MRT passengers.

Second, according to a study on urban traffic generation in the UK,[9] induced car traffic is likely to be large when the road network is operating or is expected to be operating close to its future capacity, and where elasticity of demand with respect to travel costs is high, or where implementation of a project causes large-scale changes in generalized travel costs. This is probably the case for the Bangkok traffic situation. However, it is difficult to separate the additional trip development which could be attributed to the improved accessibility provided by the new facilities from that which would have occurred anyway because of other economic conditions. For clarity, the current analysis has not taken into account the possibly induced car-traffic flow, when considering congestion relief, which could be attributed to a MRT system.

POLICY MEASURES TO STRENGTHEN THE CONTRIBUTION OF MASS RAPID TRANSIT

Certain empirical policy measures can be taken by adjusting MRT travel costs and improving MRT accessibility. These measures can also be used as basic cases for policy analysis because they are easier to implement and can provide information on the financial aspects.

Adjustment of Mass Rapid Transit Fares (Price Elasticity of Demand)

Table 4 shows the changes in MRT usage for each route (owing to different operators within the entire network) subject to a 50 per cent reduction and a 50 per cent increase from the basic fare of 25 *baht* per ride in the year 2010. The results demonstrate that MRT price elasticity for work-trip demand is less than one. In other words, a certain percentage change in MRT travel costs (input) will result in a lower percentage change in demand (output). Rationally, people are more concerned about punctuality for commuting purposes. In addition to the intensely competitive market for urban passenger travel, most Bangkok residents cannot accurately discern the real attributes of any future modes of transport. Under existing traffic conditions, time and other preferences specific to current modes (e.g., the comfort and prestige of the car) are of prime interest. Even the same type of users consider different sets of choice attributes when choosing each specific mode. It is not until Bangkok's MRT system is fully operational that transport users can fully realize the advantages which the system presents.

TABLE 4. PERCENTAGE CHANGE IN MRT USE SUBJECT TO VARIATIONS IN FARE

(in per cent)

MRT Route Operators	50 Per Cent Reduction	50 Per Cent Increase
Hopewell Company	+ 13.5	- 12.1
BTSC Company	+ 19.6	- 17.0
MRTA State Enterprise	+ 20.3	- 17.7

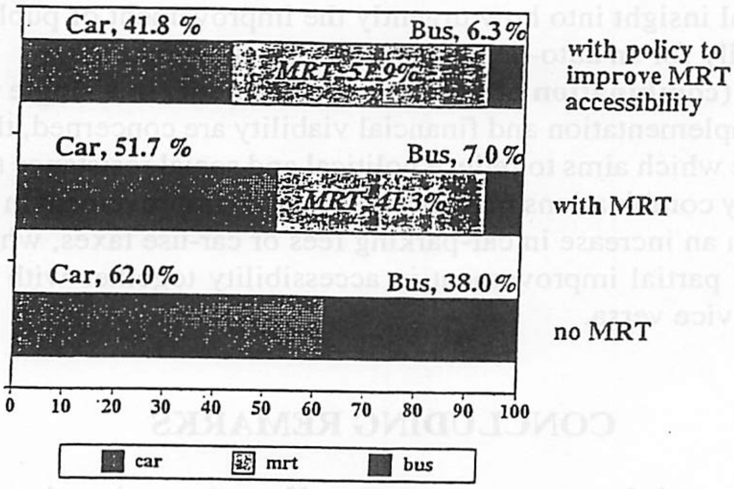
Improvement of Accessibility to Mass Rapid Transit Stations

This policy measure is important in diverting transport demand away from car use to MRT use. Essentially, to improve accessibility means to narrow the gap between the two modes. Attempts should be made to provide acceptable feeder services from all zones to the nearest MRT station(s) with reasonable travel time, cost, and frequency. The service can be justified by the scale-of-travel demands to and from the MRT stations inasmuch as access times and costs for the outer zones, with low population densities will be much higher than those in other areas.

By assuming the existence of multimodal feeder services from the zones taking less than half an hour of access time to the nearby MRT station(s), figure 14 shows a significant increase in modal shift from cars to MRT, particularly for those zones in the inner and outer suburban areas, following the improvement of feeder services. This is understandable since trip demand in the inner suburban area between the outer and inner ring roads constitutes the largest portion (around 57 per cent) of total trips throughout the whole study area. The area is undergoing rapid urbanization with no spatial development controls. Provision of roads is lagging, entailing longer travel times and higher costs. Owing to the sparse transport demand resulting from urban sprawl, the low level of public bus service provision worsens the situation in that most people living in these areas have no choice but to rely on car use. Therefore, once a new MRT system is accessible throughout the areas, the utility gap between car and MRT modes will be diminished, thus making the modal

Regional Development Studies, Vol.4, pp.65-85, 1998.

Figure 14. Change in Modal Share after Improvement in Access to MRT Services



Source: Authors' results from models analysed in this study.

shift from car to MRT much more feasible. In other words, improvement in accessibility to MRT stations will not only reduce out-of-vehicle and total travel times, it will also increase the catchment base of potential MRT users. Cross-elasticity of demand between car and MRT shares is effective under this scheme.

Policy Instruments for Further Analysis

Several interesting policy measures exist for further evaluation, including:

Direct suppression of car-use demand. To cross-subsidize MRT investment capital or to charge road users according to the marginal social costs of road usage, the government can impose various taxes on the public, e.g., introduce congestion pricing for the inner city where extensive MRT stations are to be located or in areas where associated time savings are large; increase car-parking fees or impose a development tax for car-parking space, and/or adjust input tax (fuel tax) and output tax (vehicle/km tax).

Change in the configuration of the MRT network. Since transport infrastructure consists of hierarchical networks, relieving the numerous bottlenecks which occur at certain points of the system will provide very high returns. Likewise, the majority of urban trips are within the outer ring-road area, therefore any provision of a partial or complete MRT circle line in the inner suburbs would significantly enlarge the catchment base for other potential MRT users who do not have reliable access services to the stations. This provision can be complemented by other secondary feeder services such as minibuses.

Changes in household-income levels. Income levels affect not only trip generation but also individual taste or preference regarding travel choices. This sensitivity analysis may provide fundamental planning information on the validity of model forecasts across the time frame (temporal transfer) or the process of decision making, resulting from increasing or declining incomes.

Variation of household car-ownership levels. Though car ownership seems to play only a minor role in these mode-choice models, the sensitivity test may provide practical insight into how urgently the improvement of public transport is needed, especially for an auto-dependent city like Bangkok.

Policy mix (combination of validated instruments in a single package). As far as ease of implementation and financial viability are concerned, this policy mix is a compromise which aims to reduce political and social resistance to the scheme. Promising policy combinations may include a partial improvement in MRT accessibility along with an increase in car-parking fees or car-use taxes, while an alternative would be a partial improvement in accessibility together with a decrease in MRT fares, and vice versa.

CONCLUDING REMARKS

Urban transport infrastructure represents, if not the engine, then the wheels of economic activity. It is a necessary, though not sufficient, precondition for urban growth. The demand for improved mobility or transport services is itself a concomitant part of economic growth.

Recent increasing obligations to upgrade urban mobility (particularly with regard to accessibility to public transport services) and improve environmental quality have led many third-world cities to seek effective transport policies which facilitate a reduction in car use by stimulating the development of appropriate public transport services. It can be observed that once rapid regional economic development begins, the accompanying expansion of urbanization and motorization leads to a sharp rise in travel demand. At such times, it is clear that both the supply and diversity of urban transport facilities have a determining role in the comparative levels of urban congestion. The rail transit services in developed cities provide an insight into the possibility of car-use control while at the same time maintaining high mobility to boost urban prosperity. Provision of a MRT system in Bangkok can thus be a potential solution to worsening traffic congestion.

Using an analytical framework based on stated-choice models to examine the likely distribution of future modal shares in the long term, the study suggests that, unlike evidence from some developed cities, the preference for car use in Bangkok can be effectively influenced by MRT availability, particularly when coupled with efficient access services to MRT stations. However, policies focusing on MRT fare adjustment have less influence on preferences for car use on commuting trips. This implies that for commuting purposes, people are more conscious of relative travel times and service reliability. In other words, it is essential for the government and the MRT operators to lay more emphasis on MRT operational reliability and accessibility in order to achieve a worthwhile reduction in car use. Further policy combinations based on these findings are relatively promising in prospective car-use reduction while at the same time contributing to considerable increases in MRT patronage. The correct policy mix can provide synergetic and feasible schemes with less political and public resistance, thereby becoming easier to implement. Investigations are currently underway and output will be duly disseminated.

Regional Development Studies, Vol.4, pp.65-85, 1998.

NOTES

* Joined UNCRD as a UN Researcher in April 1997 (from Nagoya University).

1/ Tetsuo Kidokoro, "Planning and Development Control Systems of Mega-Cities in Southeast Asia," *Regional Development Studies (RDS)* 1 (Winter 1994/95) (Nagoya: UNCRD, 1995).

2/ K. Phiu-nual, "Rail Rapid Transit System in Bangkok: Problems and Issues" in *Proceedings of a Symposium on Asian Urban Transportation: Bangkok Perspective* (Bangkok: Asian Institute of Technology (AIT), 1994).

3/ M. Ben-Akiva and S. R. Lerman, *Discrete Choice Analysis* (Cambridge, MA: MIT Press, 1985).

4/ W. Lan, "A Study on the Fare Structure and Pricing Formula of TRTS System" (Taipei: Department of Rapid Transit Systems, 1990).

5/ T. Morikawa and M. Ben-Akiva, "Forecasting Inter-city Rail Ridership Using Revealed Preference and Stated Preference Data" (Transportation Research Record; no. 1328) (Washington, DC: Transportation Research Board, 1991).

6/ D. Anderson and A. Borgers, "Estimated Availability Effects in Travel Choice Modeling: A Stated Preference Approach" (Transportation Research Record; no. 1357) (Washington, DC: Transportation Research Board, 1992).

7/ Bangkok Metropolitan Administration (BMA), "Project Report of the Bangkok Transport Planning Unit (BTPU)" (Bangkok, 1991); Japan International Cooperation Agency (JICA), "The Study on the Medium- to Long-Term Improvement/Management Plan of Road and Road Transport in Bangkok" (Tokyo, 1990); and Bangkok Metropolitan Rapid Transport Authority (MRTA), "Feasibility Study of the First Mass Rapid Transit for Bangkok (phase 1)" (Bangkok, 1994).

8/ C. Kessides and G. Ingram, "Infrastructure's Impact on Development: Lessons from the World Development Report 1994," *Journal of Infrastructure Systems* (December 1995).

9/ Standing Advisory Committee on Trunk Road Assessment (SACTRA), "Trunk Roads and the Generation of Traffic"(A 1994 study conducted for the Department of Transport, London, UK).