THEORETICAL AND EMPIRICAL CONSIDERATIONS ON THE INTERACTIONS BETWEEN LAND-USE AND TRANSPORT IN THE METROPOLITAN AREAS OF SOUTHEAST ASIAN COUNTRIES

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abstract : One of the most fundamental issues related to transport problems in developing countries is dramatic and rapid growth of their metropolitan areas. The aim of this paper is to identify the relationship between land-use and transport in the metropolitan areas of Southeast Asian countries. In the first part, issues are identified through the configuration of the metropolitan system, composed of both market and government sectors of land-use, transport and the environment. In the following part, interactions between land-use, transport and the environment are examined with example cases. Finally, ways of modelling land-use and transport are discussed and compared.

1. INTRODUCTION

Several decades ago, biggest economic activity concentrations of the world were situated in developed countries. During recent times this situation started to change, and cities in developing world also emerged as gigantic economic and population centres. Today, some of the world's largest metropolitan areas are located in the developing countries. This similar trend is being observed in Asia, and in the Southeast Asia in particular. However, this growth is so rapid and dramatic that the growth of population and economic activities is not paralleled by the infrastructure provision and implementation of required urban plans and policies. Today, metropolitan areas in the Southeast Asian developing countries are noted not only as the centres of economy and population but as centres of pollution and urban problems also.

During the early stages of development of these cities, most of the new investments had been attracted by the primary cities, as they could provide the necessary economic infrastructure as well as cheap labour. These investments created new jobs, attracted more and more migrants to the main city and promoted more and more investments. It was an urgent need to expand the infrastructure to support these new investments, and this has created a widening gap between the primary city and the rest of the country and established a vicious circle that hindered any possibility of slowing-down this growth, without getting adverse economic consequences.

2. CHARACTERISTICS AND ISSUES OF METROPOLITAN AREAS OF SOUTHEAST ASIAN COUNTRIES

The fast and dramatic growth and the subsequent urban sprawl of Southeast Asian metropolises has caused uneconomical location of activities that ultimately lead the way to many transportation related problems, such as heavy traffic congestions and subsequent air pollution.

Another issue which is common to Southeast Asian metropolises is the overcrowding of the city. Capital cities in Southeast Asian region have higher Indexes of Primacy; the ratio of capital city's population to that of the second largest city. In Bangkok this was as high as 33.8 and in Manila and Jakarta it was 5.0 (ESCAP, 1993). This primacy holds not only in terms of the population, but the share of GDP, registered vehicles, employment, person-trips and the average living standards. Due to this economic disparity between the metropolis and the rest of the country, many migrants, mainly low-income illegal settlers, are attracted to the city centre, in search of employment in the informal sector, which is very significant in the metropolises in the region. In most of the Southeast Asian metropolises, employment created by the informal sectors account for almost half of the jobs. in 1980, employment in informal sector accounted for 65% in Jakarta, 50% in Manila and 49% in Bangkok (ESCAP,1993). The presence of this informal sector job opportunities in one way encourages the low-income migration and consequently sub-standard or illegal settlements.

One cannot discuss the land-use, transport and the environmental situation of Southeast Asian developing metropolises without taking this low-income sub-standard housing into consideration. The existence of this income group is so significant that more than one third of the urban population was under the poverty line in most of the metropolises in the region (ESCAP,1993). Suffered by both the unaffordable land prices as well as transport costs, most of the low-income people settle illegally in the areas closer to the informal job opportunities, even though the risks of pollution and natural hazards are high. This gives rise to an additional urban problem of deteriorated health conditions. These areas usually are not served with proper sanitary services, simply because the settlements are 'illegal'. The risks of these illegal settlements range from the natural hazards such as floods; health hazards caused due to the close proximity to waste dump sites; or the risk of being exposed to industrial pollutants. Apart from these, malnutrition, water-borne diseases, indoor air pollution are also very common.

Southeast Asian metropolises usually have low road-area ratio; in Bangkok this is only 9%. They also record increasing motorization. Provision of public transport, especially non-road-based, is often inadequate. As an example, in a city of 8.2 million inhabitants, Bangkok has only 60,000 daily rail commuters (Wanisubut,1993). Together, they lead to increased road traffic congestions. Peak hour traffic flow speeds are as low as 7 mph in Manila (ESCAP,1993) and 6 kph in Bangkok (Wanisubut,1993).

The social attitudes towards public and private transport add to the problem. As in most developing countries, in Southeast Asian metropolises private car is a symbol of status or prestige. In the absence of proper public transport, these attitudes cause ever increasing private car use. A study in Bangkok has revealed that the cumulative effect of extremely inadequate school buses and the parental attitude of using private cars for the school trips can induce one third of the peak time traffic congestion (Fan and Tanaboriboon, 1992).

Today's transportation related problems in the Southeast Asian metropolitan areas cannot be solved by overlooking the land-use set up and by implementing transport related measures alone. It is important to understand the contribution of the land-use distribution on the transport, identify the interactions between land-use and transport and to take an integrated approach in handling the transportation issues in the Southeast Asian developing metropolises.

This paper is an effort in understanding the land-use and transport interaction in the developing metropolitan areas of Southeast Asia and formulating an integrated modelling approach that can serve in addressing the growing urban problems.

3. INTERACTIONS BETWEEN LAND-USE, TRANSPORT AND THE ENVIRONMENT

3.1 The Metropolitan System

A metropolis can be considered as comprising of three mutually interrelated sectors of land-use, transport and the environment. Each of these sectors further composes of the market or the situation and the related governmental agencies. While the land-use and transport constitute markets, environment can be assumed as an externality of both land-use and transport, and it does not constitute a market presently by itself. This metropolitan system presented in a configuration by Miyamoto and Udomsri (1994), is shown in the Figure 1.

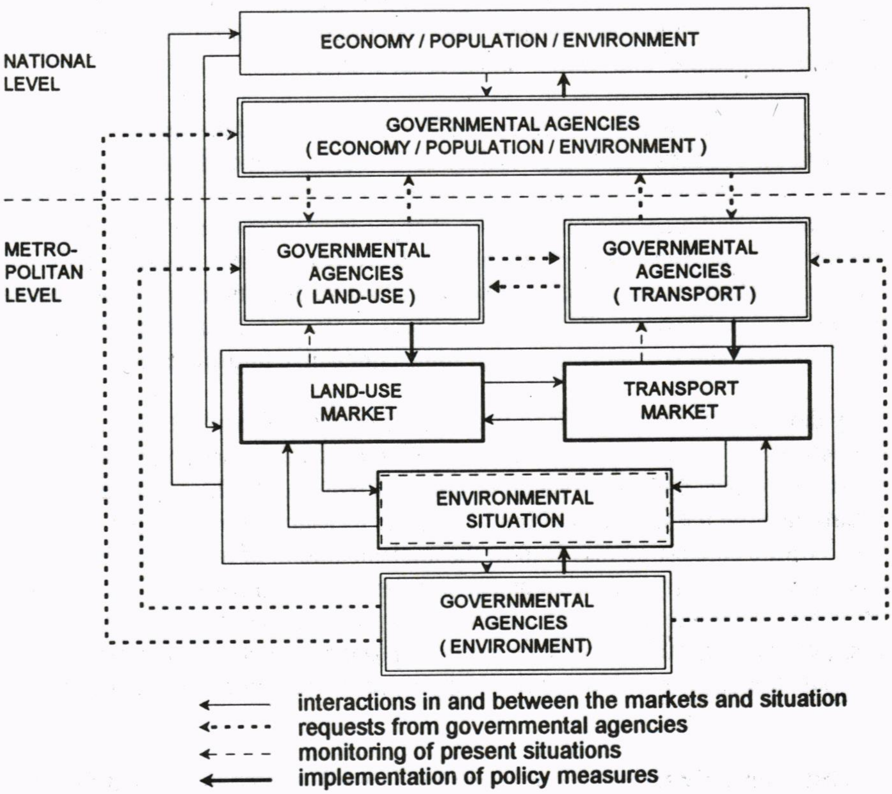


FIGURE 1 CONFIGURATION OF THE SYSTEM OF GOVERNMENTAL AGENCIES, LAND-USE AND TRANSPORT MARKETS, AND ENVIRONMENTAL SITUATIONS IN A METROPOLIS [source : Miyamoto and Udomsri (1994)]

Land-use and transport situations are determined by the market conditions and the conditions given by the other related markets. Environmental situation is the outcome of land-use and transport situations. Markets and situations at the metropolitan level have also interactions with the economic and environmental situations at the national level (Miyamoto and Udomsri, 1994). Among these kinds of interactions in the metropolitan system, discussion in this paper is limited to the interactions between land-use and transport markets and the environmental situation.

Present situations of land-use, transport and the environment affect future markets and situations of land-use, transport and the environment. It is convenient to discuss the interactions by separating them according to 'cause and effect'. However, these 'effects' consequently act as 'causes' for further impacts leading to a chain of secondary and tertiary impacts in different sectors. For example, transport improvements to a remoted zone primarily increases the residential density, and as a result of it, in the secondary stage the solid waste generation will rise in the environment sector, and causes increased transport demand in the transport sector. This in the latter stages of the chain will cause severe traffic conditions and subsequent air pollution along the corridors. We, therefore, consider here only the primary and direct impacts of the present situations, that are felt immediately in the same period, or in the following time period, with some time lag. The effect of a change in the situation in one sector can be felt in another sector immediately or with a time lag. In Table 1, the interactions between land-use, transport and the environment sectors of a metropolis are presented, with 'immediate' and 'future' impacts separately.

The criteria to distinguish whether an impact is 'future' or 'immediate' impact was based on whether the change requires building or facility construction of a certain scale, that requires physical time. It is observed that land-use market is affected mostly by the long-term prevailing situations and response time for the changes is not immediate. On the other hand, some transport related decisions such as infrastructure expansion, are based on long-term changes in the situations whereas some other decisions such as mode or route choice, are based on immediate situations. Environment situation is merely a reflection of current situations of land-use and transport, although some cumulative impacts exist.

It is not only the present situation of land-use, transport and environment that determines the future situations of the three sectors. Future markets and situations are greatly affected by the implementation of policy measures related to different sectors. On the other hand, worsened present situations urge the implementation of counter measures. For example worsening air quality due to traffic congestion may lead to the implementation of traffic regulatory policies, or the implementation of traffic management policies may eventually lead to improved air quality. However, such interactions as situations on policy measure implementation are not discussed in this paper, for this study does not intend to model such decision making process. The goal of this study is to provide a tool to support such decision making of policy measure implementation.

Interactions between different sectors of a metropolis are discussed in detail in the following sections.

TABLE 1 SOME EXAMPLES FOR THE INTERACTIONS BETWEEN SITUATIONS AND MARKETS OF LAND-USE TRANSPORT AND THE ENVIRONMENT

New Situation / Previous Situations	Land-Use Market	Transport Market	Environment Situation
Land-use Situation	- Attitude Factors in the Locator Choice (Usually Considered under Zone Characteristics) (FUTURE)	- Infrastructure and Operation Expansion according to Previous Land-Use Distribution (FUTURE)	
		- Trip Generation according to the New Land-Use Distribution (IMMEDIATE)	- Land-Use Originated Pollution (IMMEDIATE)
Transport Situation	- Accessibility Factors in the Locator Choice (FUTURE)	- Basis for Infrastructure expansion according to previous Transport Condition (FUTURE)	
		- Basis for the Route and Mode Selection according to New Situations (IMMEDIATE)	- Transport Originated Pollution (IMMEDIATE)
Environment Situation	- Environmental Quality Factors in the Locator Choice (FUTURE)		- (Few)
		- (Few)	

3.2 Land-Use on Land-Use

In most cases, one of the important factors that determine the land-use in an area is the existing land-use. Concentration of a particular type of activity in an area not only affects the recognition of zones for land-use zoning, but affects the locational utilities for different locators through attitudes.

There is always an inertia for the change of location. This is particularly true not only for the residential locator, but commercial and industrial locators as well, although their reasons are different from each other. Residential locators have a psychological effect of familiarity and the commercial and industrial locators are reluctant to move due to reasons of stability and establishment. Unless justified by the merits and advantages of moving, there always is an inertia to move.

A new locator has a tendency to locate in an area which is recognised for the particular activity. The term ***Recognition*** here apply not only for recognition by local authorities or by land-use regulations, but the general attitude of the locators also.

Another factor which is a governing factor, especially for the residential locator, in Southeast Asian developing metropolises, is the socio-economic segregation of the locators. Residential locators of the high income group tend to locate in areas where there is a reputation as a high-income residential area. On the contrary, they are reluctant to locate in areas where there are lot of low or middle-income residents. This causes a socio-economic segregation among the residential locators. This is also the case for racial and religious segregation

It is difficult to express or quantify the reluctance to move, socio-economic attraction or repulsion in mathematical relationships simply because these factors are closely linked with cultural and social background of the locators. One thing is clear; that locator choice has a strong relationship with the existing land-use distribution. The degree of relationship is to be established based on practical evidence. In a land-use simulation, current land-use distribution can be one of the explanatory variables that explain the locational utility. Indirectly, this will represent the attitudes towards moving and segregation according to the social class.

3.3 Land-Use on Transport

The most important interaction in a metropolitan area lies between the land-use and the transport. The distribution of land-uses in a metropolitan area defines the generation and attraction of trips. Spatial interactions to generate trips are shown in the Figure 2.

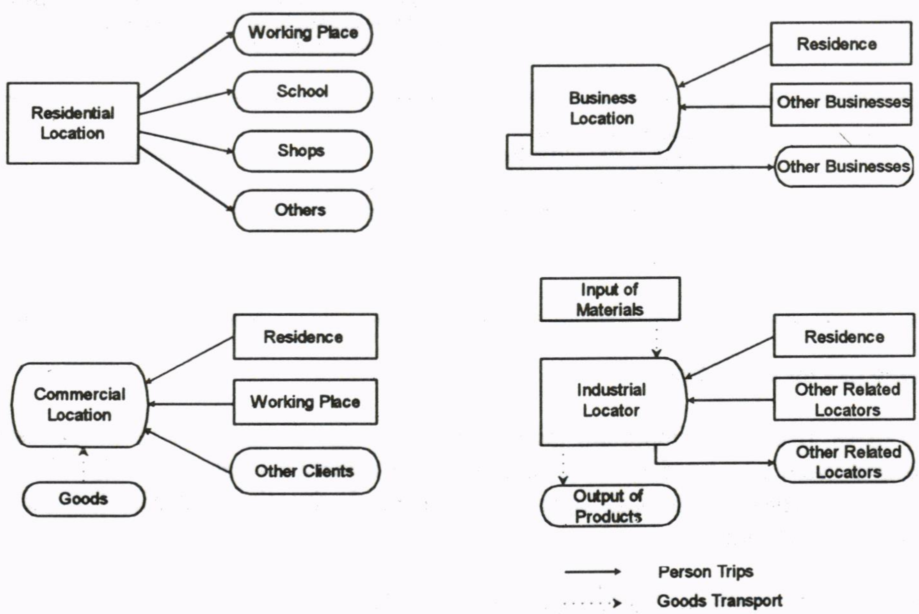


FIGURE 2 SPATIAL INTERACTIONS TO GENERATE TRIPS

Trip production by a unit of locator (trip production rate) for a particular purpose is a characteristic of the locator group. These rates are the functions of the socio-economic and cultural backgrounds of the population. The trip production rate also vary with the accessibility due to widening life opportunities. In this case, trip production rate does not hold constant. Therefore, in actual practice, we have to add a function to relate the trip production rate and accessibility. For simplicity, in the following derivations, trip rates are treated constant. The product of the number of locators belong to a particular locator group in a zone and the trip production rate for a particular purpose gives the total number of trips generated from the zone, by the locator group for the purpose.

Land-use distribution affects the trip pattern through the destination choice also. Relative location of candidate destinations and the originating zone affects the accessibility. However, apart from the accessibility factors, other factors such as quality of service at the destination affect the destination choice. Sometimes, the choice of the destination is not flexible (for example, trip to work or school). Sometimes there can be plural number of destinations for the same purpose (for example, shopping trips, business related trips). This can be true for the origin of the trip also. (Table 2)

The destination choice of a particular locator group, located at a particular zone, for a particular trip purpose, can be expressed as a function of the accessibility factors, determined by the lower choice level of mode choice, and the other explanatory variables representing characteristics at the origin and the destination etc.

TABLE 2 EXAMPLES FOR TRIP CLASSIFICATION ACCORDING TO THE FLEXIBILITY AT ORIGIN AND DESTINATION

Origin \ Destination	Fixed (Single)	Fixed (Multiple)	Non-Fixed
Fixed (Single)	Trip to Work, School	Delivery of Products to Wholesalers	Shopping trips
Fixed (Multiple)	Raw material transport to an Industrial location	Business trips to Other Business locations	
Non-Fixed	Trips to airport		Trips while shopping (one shop to another)

In addition, interactions between land-use and transport may be explained as interactions between land-users, households, commercial and industrial activities, etc., most of which are observed as traffic between them. Some of the interactions have fixed origin and destination (fixed interaction), e.g. work and school trips, whereas others have flexible destinations or origins (flexible interaction), e.g. shopping trip, as described above. In the first place, the interactions, either fixed or flexible, can be classified into three categories according to the time when the interaction is established, as shown in Figure 3. Existing, new and changed interactions mean those which exist before the present period, those which are established in the present period and those which are changed in the present period, respectively. It should be made clear here that the classification applies not to the location of interactions, but the interactions themselves, as the changes in the location are to be considered in the next step.

In the next step, the interactions are also classified from the viewpoint of the change of land-user's locations in the present period. Figure 4 shows the possible changes in the location of a particular land-user. The dark square represents the location of the land-user at a given period. There can be six possibilities; No-move, Relocation, Move-in, Move-out, Generation and Demolition. Any given land-user falls into one of these categories. However, this does not include the intra-zonal relocation or changes due to re-definition of study area. Table 3 shows the classification of interactions where "no move", "relocation" inside the study area, "move-in" from outside the study area, "generated" in the study area, mean that the location of origin or destination is inside the study area. Conversely, "move-out" the study area and "demolished" in the period mean that location is outside the study area and the interaction no longer exists.

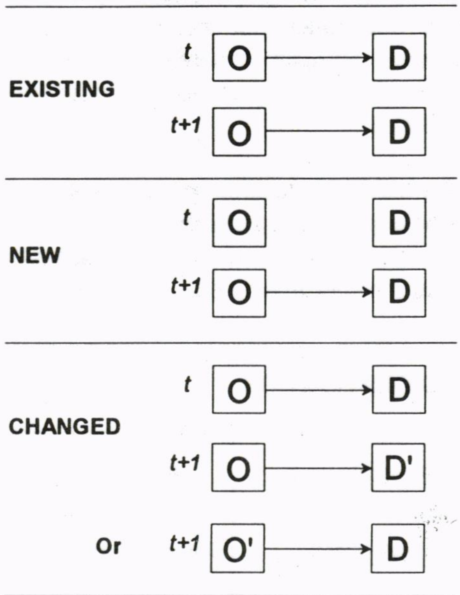


FIGURE 3 INTERACTIONS BETWEEN LAND-USERS (Regardless of the Locations)

TABLE 3 CLASSIFICATION OF INTERACTIONS BETWEEN LAND-USE AND TRANSPORT

Destination / Origin	No move	Relocation	Move-In	Generated	Move-Out	Demolished
No move	NN	NR	NM	NG	(NO)	-
Relocation	RN	RR	RI	RG	(RO)	-
Move-In	IN	IR	II	IG	(IO)	-
Generated	GN	GR	GI	GG	(GO)	-
Move-Out	(ON)	(OR)	(OM)	(OG)	-	-
Demolished	-	-	-	-	-	-

( ) : interactions with land-users outside the study area
- : interactions don't exist any more in the study area

This kind of classification of land-use and transport represent how and when the interactions are established. In Table 3, the location changes "no move", "relocation", , "move-in", "generated", "move-out" and "demolished" are denoted as N, R, I, G, O and D for both origins and destinations. Existing, induced and diverted traffic are examples of existing, new and changed interactions belonging to "NN". In most cases of housing location choice, the distance from working place is a major location factor. Such kind of interaction are represented by either "NN", "RN", "IN" or "GN". On the other hand, in other case of work place choice, location of housing is given to the interaction set-up. In this case, the interactions belong to either "NN", "NR", "NM" or "NG".

In the stage of modelling the interactions, the level of aggregation of land-users have to be carefully examined to represent location factors for each land-use group as well as time factor for simulation based on the above-mentioned consideration from the individual viewpoints.

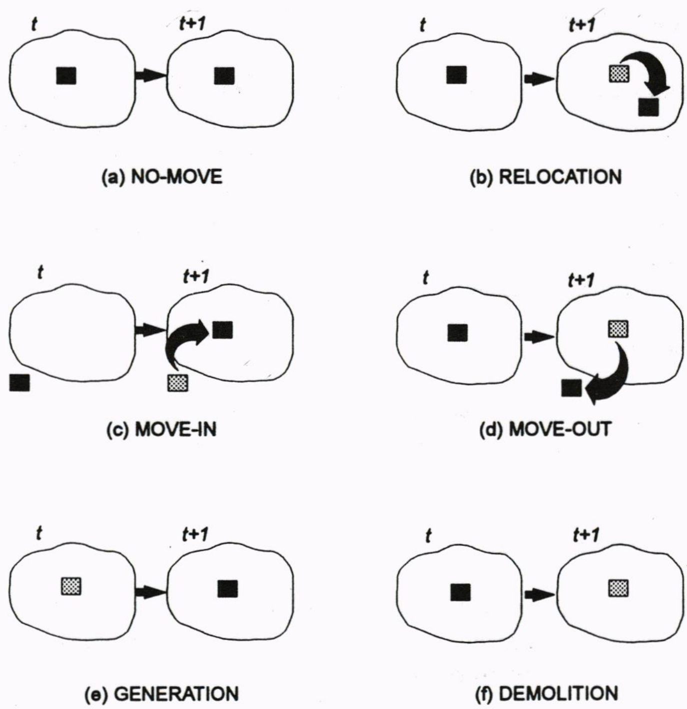


FIGURE 4 CHANGE OF THE LAND-USER'S LOCATION DURING PERIODS *t* AND *t+1*

3.4 Land-Use on Environment

Effects of the land-use on the environment, especially from the residential and commercial land-uses, had often been disregarded in the urban planning models. Out of the land-use originated environmental impacts, air and water pollution due to industrial activities had long been identified as a environmental problem. But there is a considerable impact on the urban environment from the residential and commercial activities also. With the dramatic expansion and overcrowding of metropolises, especially those in the Southeast Asian region, urban problems such as the disposal of solid waste, sewerage and associated water pollution, etc. have cropped up. The change of land cover from vegetation to impervious pavings causes other problems such as drop of local water table and climatic changes through urban heat island effect, etc.

It has been found that the rate of pollutant emission has a close relationship with the activity level of an area. For example, solid waste generation rate per capita in a zone is proportional to the residential activity level. A good indicator of the activity level is the land price of the area. A relationship can be established between the land price and the emission rate of each of the pollutants for different land-use categories (Miyamoto and Sathyaprasad, 1995).

Regarding environmental impacts due to the change of land cover also, it is possible to establish relationships between the land price and the land cover composition. Environmental impacts due to land cover changes can be estimated if the land cover composition is known.

3.5 Transport on Land-Use

Accessibility factors affect the locational utility to a greater degree. A zone well served by transport facilities increases the locational utility of the zone. Characteristics of transport facilities to a zone determines the travel times along different routes to different locations of the metropolis. In the integrated model accessibility is modelled as follows. Destination choice is ultimately based on the route choice, which is simply obtained by summing up the utilities of the links that constitute the route. Route choice is expressed in terms of the locator group, locating zone, trip purpose, destination, and the mode.

3.6 Transport on Transport

Transport related factors such as travel time, mode choice, route choice, link traffic, etc. are interrelated. The relationships between these factors is discussed separately in the next chapter.

3.7 Transport on Environment

Environmental impacts of transport had been the topic of discussions on the urban problems as the consequences are evident in any metropolis. Metropolitan areas in Southeast Asian region are examples of this. Environmental impacts of transport are mostly immediate, and includes gaseous emissions such as NOx, CO, hydrocarbons etc., noise and vibration and transport related energy consumption etc.

Many studies conducted on the emission behaviour of vehicles had found that different gases have different emission behaviours on the speed of the vehicle. For a given traffic flow, pollutant emission can be estimated if the speed of the flow is known. Noise pollution and the energy consumption also have the similar behaviours on the speed and traffic flow. Traffic flow and speed are two variables available from the link flows discussed in the previous section.

3.8 Environment on Land-Use

Out of the factors which determine locator choice, environmental quality of the zone is one important factor, especially for the residential location. This group of factors include the ambient air quality, water quality, green space per inhabitant etc. Sensitivity to each of these factors is a characteristic of the locator group. For example, an industrial locator will not be sensitive to the ambient air quality to the extent a residential locator is. The parameters that represent these sensitivenesses should be established through sample calibration, as it is also a characteristic of the people of a particular metropolis.

3.9 Environment on Transport

Effect of environment on the transport is very weak. Although there can be some effects like effect on the route choice for non-motorised trips, these can often be disregarded.

3.10 Environment on Environment

This is another weak relationship. Except for the effects of public opinion and environmental regulations to preserve ecologically or environmentally sensitive areas etc. there are no many impacts, and hence can often be disregarded.

3.11 External Factors on Land-Use, Transport and the Environment

Several other external factors, including some national or higher level agencies and situations affect the degree to which the land-use, transport and environmental interactions hold. For example, some natural factors such as the topography and geographical location of a metropolis will decide the severeness of the accumulated air pollutants over the city. These factors include economy, population growth and natural factors, etc.

4. MODELLING INTERACTIONS BETWEEN LAND-USE AND TRANSPORT

4.1 Interaction models and Integrated Models

Urban land-use and transport have a tight interaction between each other, and that any transport or land-use specific policy will affect the other sector, though not necessarily on the same time scale. Therefore there have been a general consensus among the urban model builders that both of these sectors and their interactions are to be taken in to consideration in order to predict the changes in either of the two sectors.

Nevertheless, there have been different approaches in modelling these interactions. There appear to be two types of procedures to simulate land-use and transport changes; by linking independently developed land-use and transport models through inputs and outputs, and integrating both in a single model framework. Depending on the procedure to simulate the interaction between land-use and transport, there are two types of models.

Models belonging to the first type are actually composed of independent land-use and transport sub-models interacted only through the outputs of each other. In this paper we call this type of models as Interaction Models. The second type models are those in which land-use and transport are organically integrated in a single model framework. We call this type of models as Integrated Models. This distinction is somewhat similar to the Wegener's 'composite' and 'unified' models (Wegener, 1994). Basic structures of these models are shown in the Figure 5. Out of the contemporary urban models, models with organically integrated sub-models such as BOYCE (Boyce and Lundqvist, 1987), 5-LUT (Martinez, 1992) and RURBAN (Miyamoto and Udomsri, 1995) can be considered as Integrated Models whereas models with hierarchically interconnected sub-models such as TRANUS (de la Barra et al, 1987), MEPLAN (Echenique et al, 1990) etc. as Interaction Models.

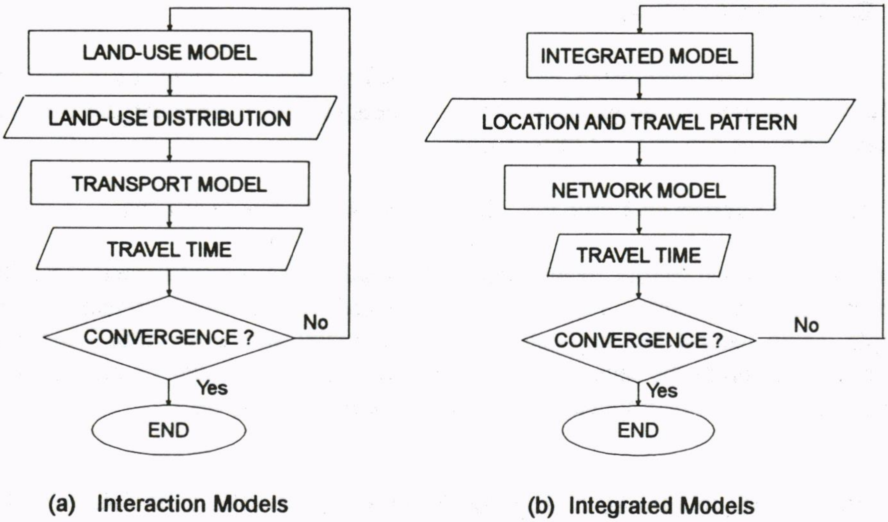


FIGURE 5 BASIC STRUCTURES OF INTERACTION AND INTEGRATED MODELS OF LAND-USE AND TRANSPORT

4.2 Interaction Models

The Interaction type of models assume that the city can be considered as comprising of a sequential and independent hierarchical system of land-use and transport. These two sub-models have separate independent internal structures, and connected to each other through inputs and outputs. In other words, land-use sub-model achieves the equilibrium independent of the transport sub-model. Therefore the final converged travel times from the transport sub-model may or may not be consistent with the travel times used for the land-use forecast in the previous iteration. In this type of models, location and transport are not determined simultaneously. But interaction type of models are easier to develop, include other sub-models, calibrate and to validate, as each sub-model can be developed, calibrated and validated independently.

4.3 Integrated Models

Integrated model considers the location and travel pattern are the outcome of the same choice process. Travel behaviour is considered as a lower level of the same choice hierarchy, where location choice represents the higher level. Equilibrium is obtained from the convergence of the integrated model, which simultaneously determines the location and travel pattern through the spatial interaction. Location and travel pattern are the input variables in the network model that estimates travel times. Hence the converged land-use distribution and travel times are both consistent with those used in the previous iteration simultaneously. However, the development, incorporation of other sub-models, calibration and validation of the integrated model is not convenient. Despite these difficulties, integrated models are more theoretically consistent and can be more operational.

The two types of models have their own advantages. As the equilibrium of integrated models are reached at the converged land-use distributions and travel times simultaneously, they are theoretically more consistent than the interaction models, where the converged land-use distribution is achieved not necessarily at the converged travel times. On the other hand, the model structure of the interaction model is simpler and makes it easier to program, debug and calibrate, as it is possible to develop each sub-model independent of another. This also makes it easier to add new sub-models to represent any sector of the metropolis even at a latter stage. Integrated models lack these advantages. Integrated models can reach the convergence at a lesser number of iterations but are more data intensive. Table 4 shows a comparison of the relative merits and demerits of interaction and integrated models.

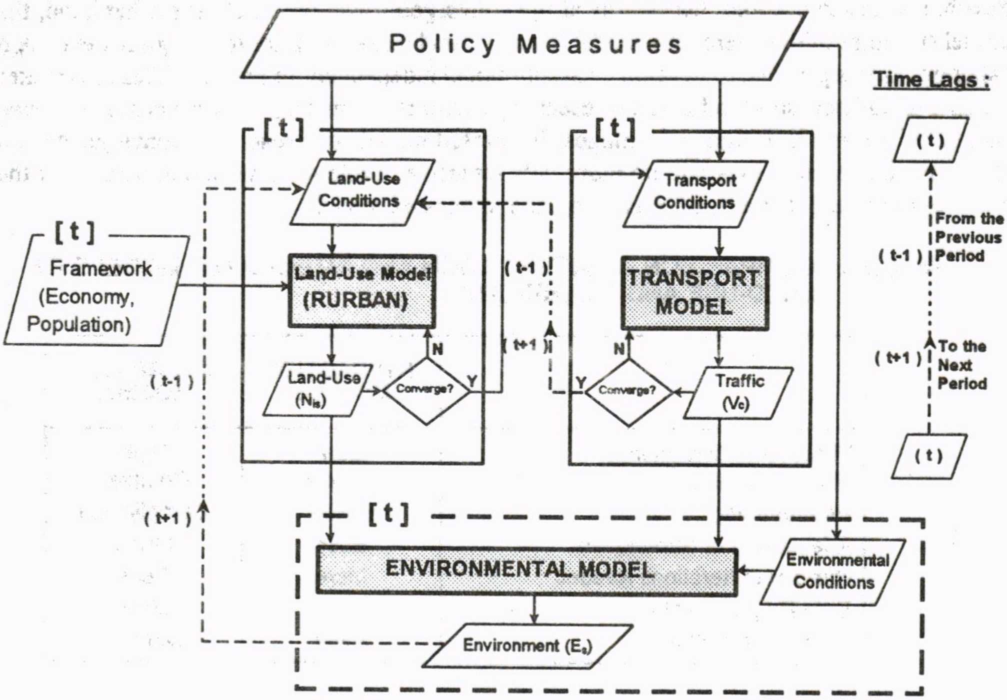
TABLE 4 COMPARISON OF INTERACTION AND INTEGRATED MODELS OF LAND-USE AND TRANSPORT

	INTERACTION MODELS	INTEGRATED MODELS
Theoretical Consistency	Low	High
Model Structure	Simple	Complex
Programming	Easier	Complicated
Adaptability of Sub-models	Easy	Difficult
Number of Iterations Needed	More	Less
Data Requirements	Less	More
Calibration Method	Easy	Difficult

4.4 An Integrated Model of Land-Use and Transport [Miyamoto and Udomsri(1995)]

In this section the structure of a proposed integrated model of land-use and transport is discussed. This integrated model is based on the land-use model RURBAN (Random Utility/ Rent-Bidding ANalysis) (Miyamoto *et. al.*, 1992). The basic concept of the RURBAN model is based on the random utility theory and the random rent-bidding analysis. In RURBAN, the general equilibrium of the land market is obtained under the condition that the demand for land derived from the random utility theory and the supply of land derived from the random rent-bidding analysis are equal. Figure 6 shows the structure of an Integrated Land-Use, Transport and Environment Model [modified from Miyamoto and Udomsri (1995)].

In the integrated model, RURBAN is improved to incorporate the transport choice within the location choice. The choices of location and trip are viewed as outcome of a probabilistic choice process. The process is simply described by four levels of choice hierarchy in decision-making chain starting from location choice and destination choice in land-use level, to mode choice and route choice in transport level. This choice tree structure is shown in the Figure 7.



N_{is} : distribution of land-use (*i*) in zone (*s*)
V_c : velocity on transport link (*c*)
E_s : environmental indicators for zone (*s*)
t-1, *t*, *t+1* : time periods

FIGURE 6 THE STRUCTURE OF AN INTEGRATED LAND-USE, TRANSPORT AND ENVIRONMENT MODEL [modified from Miyamoto and Udomsri (1995)]

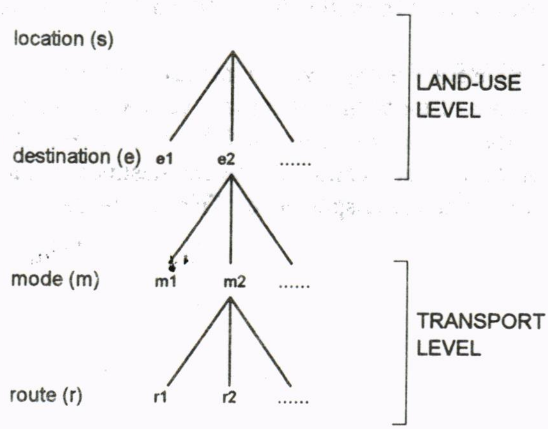


FIGURE 7 THE HIERARCHICAL CHOICE TREE STRUCTURE FOR ACCESSIBILITY IN THE INTEGRATED MODEL

5. CONCLUDING REMARKS

Developing metropolitan areas, particularly those in the Southeast Asian region, are characterised with numerous urban problems, roots of which lie in the land-use set up. Transport related problems in these cities can not be addressed by transport related measures alone. The interaction between land-use and transport in these metropolises should be well understood first. Then the issues should be addressed with an integrated approach.

The interactions between land-use, transport and the environment are discussed in the first part of the paper. The kind of integration that can be modelled varies from the sequentially integrating independent sub models to integrating all sub models organically to one. The structure of an integrated model is discussed in the latter part of the paper.

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