CAN URBAN TRANSPORTATION COPE? -TRANSPORTATION GAP MODELING FOR ASIAN CITIES: THE CASE OF METRO MANILA -

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Abstract: This paper has two objectives. The first is to compare the socio-economic and urban transportation characteristics of some Asian cities. The second is to present the concept of TG (transportation gap) modeling using actual financial and operational data on urban transportation for one city in the study area. Using the parameters demand density and city size, performance domains of the different modes and the resulting TGs are modeled. Policy variables (loan interest rate, government subsidies, and congestion ratio) are incorporated in the TG models. The effects of changing the values of these policy variables on the performance domains and on the resulting TGs were simulated and analysed.

1. INTRODUCTION

1.1 Background

Prior to the regional financial crisis, Asia has been the center of rapid and dramatic economic growth in the world. The shift from basically agricultural to industrial economies has been observed in a number of countries in the region. Socio-political and economic activities and functions have grown accompanied by changes in the urban landscape of the countries' capitals. But the economic recession in the region has led to fewer resources available to the provision of transportation. With scarce resources and with economic uncertainty still lingering in Asia, questions remain concerning the future of transportation in the region. It is therefore important that different modes operate efficiently. It is necessary to find the most appropriate transportation system considering the characteristics of the cities and of the population.

1.2 Objectives and Study Area

This paper has two objectives. The first is to compare the characteristics of urban transportation in some cities in Asia. Basic parameters representing urban transportation characteristics are selected and compared. The second is to perform transportation gap modeling. This is to identify the performance domains of transportation modes considering the characteristics of the cities and simulate the effects of certain policy variables on these performance domains. The study area is composed of Bangkok, Jakarta, Kuala Lumpur, Metro Manila, and Singapore.

The second chapter of the paper discusses the analytical framework of the study. The third presents the urban transportation characteristics of the study area. The fourth presents results of the TG modeling for one city (Metro Manila) in the study area. The last chapter presents the paper's conclusions and future research directions.

2. ANALYTICAL FRAMEWORK

2.1 The Forces of Demand and Supply

The effectiveness of transportation is a result of the interaction between the forces of supply and demand. Forces of supply include capacity, level of service, fares, facility of access/egress, and other characteristics of the transportation mode. Demand forces are the characteristics which influence travel demand such as population density, size of the working population, socio-economic characteristics, urban structure, etc. There usually exists a choice between using a certain mode over another due to that mode's higher attractiveness. The choice between taking a train or one's own car in traveling to the central business district is a typical example. Factors like travel time (inclusive of access, egress, and waiting time for public transportation and travel time for private transportation) and generalized travel cost (travel time cost and fare for public transportation and travel time cost, fuel cost, parking cost, and road pricing cost for private transportation) can influence the modal choice of travelers.

It is important and necessary to take both supply and demand into account in order to develop an efficient and effective transportation system. In this study, an attempt is made to propose a simple and quick-response tool for this purpose.

2.2 Supply Side Analysis: Transportation Gap

The characteristics of a city influence the kind of mode that is appropriate to it. A transport mode is appropriate for a certain level of travel demand density and city size. Urban rail, for instance, is best for big cities with corridors of high travel demand. Buses suit medium size cities with relatively lower travel demand. Smaller scale and less expensive transport systems are suitable for smaller areas with smaller demand densities. It is therefore logical to identify the optimum domain of modes using travel demand density and city size as parameters.

Considering a cartesian coordinate system where the vertical axis is demand density (such as in persons per hour-km) and the horizontal axis is route length or distance, the performance domain of a transportation mode is defined as follows:

- Upper bound: physical capacity of the mode in terms of demand density (Line A)
- Lower bound: financial capacity of demand (Line B)

- Right bound: maximum distance of the mode (Line C)

The performance domain of a mode can be viewed as the optimum domain of application of that mode. It represents the set of conditions (i.e., demand density and city size) where the mode operates within its physical capacity and financial viability. It is dependent on the mode's physical and financial characteristics. Because modes differ in characteristics, they are expected to have different domains although there may be certain overlaps of domains to some extent. The so-called transportation gap (TG) is the area(s) in the cartesian plane that is *not* covered by any of the domains of the existing transportation modes.

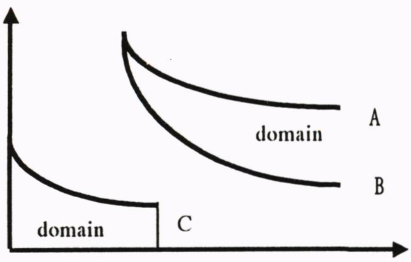

Figure 1. Domain of a Mode

The domains and the resulting TGs are functions of certain policy variables. It is therefore possible to check the effects of changing the values of the variables on the domains and TGs. Policy simulation will be done and the effects of different policy variables on the TG will be analyzed.

2.3 Demand Side Analysis: Modal Advantage Area

The characteristics of a mode influence its utility to users. Travel time and cost incurred in using a certain mode affect its attractiveness over other modes. Traveling to the CBD is usually a choice between taking public transportation (train, bus) or private car. The choice largely depends on which mode will require shorter travel time (including access, egress, and waiting time for public modes and driving time for cars) and lower generalized travel cost (travel time cost and fare for public modes and travel time cost, fuel cost, parking cost, and road pricing cost for private car).

Shorter travel time and lower generalized travel cost define the advantage of one mode over another. It is then possible to physically identify or delineate the areas in cities where taking a certain mode (train, for instance) is better than taking another (say, private car) in going to the CBD. Such areas are called the advantage area of that mode. In big cities in Japan for instance, it is mostly more advantageous to take railways instead of cars in traveling to the CBD because of shorter travel time and lower total cost. Railway advantage areas can be determined for these locations. This can also be applied to any other competing modes. In the case of Asian cities, it may be appropriate to consider the competition between the bus which is the dominant public mode and the private car in determining the modal advantage area.

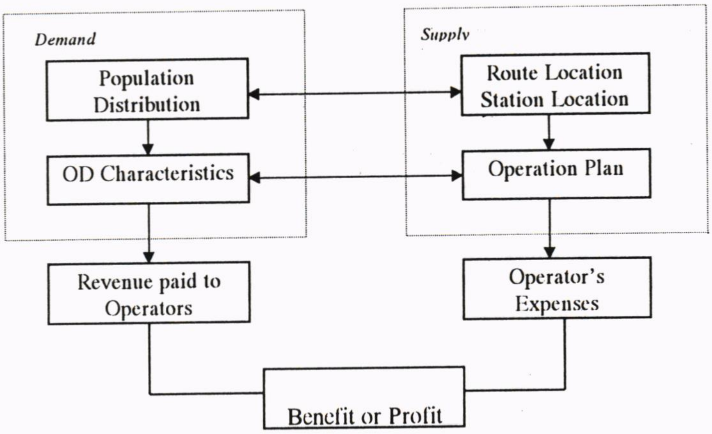

Figure 2. Supply and Demand Side Analysis and Policy Simulation

The determination of the modal advantage area also indicates the expected demand density that a mode will serve. It is then possible to compare this estimated demand density with that of the modal domains identified in TG analysis. It can then be determined if the estimated density derived from the analysis of modal advantage areas (demand side analysis) matches the demand density of the domain resulting from the TG models (supply side analysis). In other words, it can be checked if there is sufficient demand density for a certain mode. Discrepancies in the comparison can be analysed and policy simulation can be performed to see the effects of policy changes on the discrepancies. Figure 2 shows the conceptual framework of supply and demand side analysis and policy simulation.

The present study focuses on supply side analysis or TG modeling. Demand side analysis is included in the forthcoming stages of this research.

2.4 Study Flow

Figure 3 shows the flow of TG modeling used in this study. It consists of four modules: the physical capacity module, the financial capacity module, the domains and TGs module, and the policy simulation module. Recent actual data are used in the physical capacity and financial capacity modules. With the output from these two modules, performance domains of the modes are established and resulting TGs are determined. Policy simulation is performed using different variables. New domains and TGs are established.

3. CHARACTERISTICS OF THE STUDY AREA

These characteristics are the inputs necessary if one is to perform the whole supply side and demand side analysis and policy simulation. Demographic and socio-economic information are needed for establishing the trip demand distribution. Characteristics of modal split, congestion, and of private and public transportation are bases for the determination of modal advantage areas. The use of more detailed data in the performance of TG modeling will be illustrated in the next chapter.

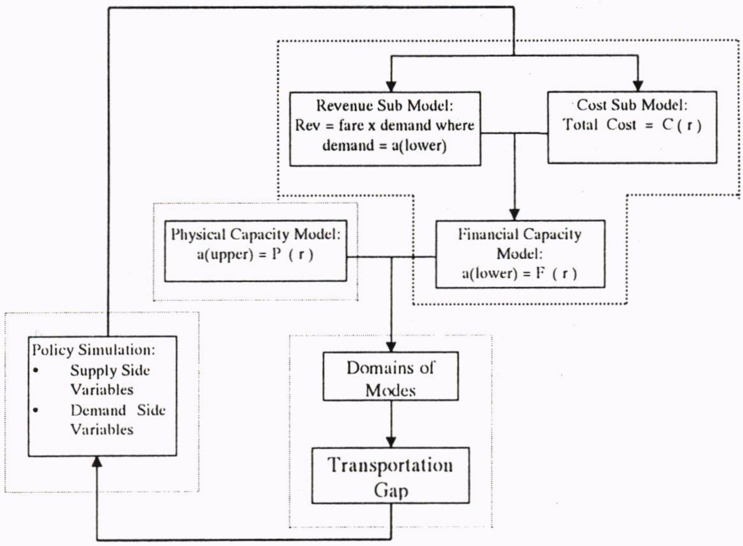

Figure 3. Flow of TG Modeling

3.1 Demographic and Socio-economic Characteristics

Urban areas in most countries in Asia are characterized by rapid population increase due to natural growth and rural-urban migration. Rapid urbanization is a typical trend in most Asian countries. Table 1 shows national and urban populations of the study area demostrating a consistent increase in percentage of urban population. Table 2 shows increasing population densities in the study area.

Table 1. Population in the Asian Region (1970 - 2000, in millions)

Country	1970		1980		1990		2000	
	Total	Urban (%)	Total	Urban (%)	Total	Urban (%)	Total	Urban (%)
Thailand	35.7	13	46.7	17	55.6	23	63.8	29
Indonesia	120.3	17	148.3	22	181.6	31	213.5	39
Malaysia	10.9	34	13.8	35	17.8	43	22.0	51
Philippines	37.5	33	49.3	37	62.6	43	66.2	49
Singapore	2.1	100	2.4	100	2.7	100	3.0	100
Japan	103.7	75	116.8	76	123.5	77	128.7	78

Source: Asia and EMENA Population Projections
Urban Transportation in Asia; World Bank Technical Paper Number 224

Car Ownership and Income

The private car has always been a symbol of prestige as well as personal mobility. Rising car ownership levels are typical trends in developing countries because of the increasing purchasing power and growing incomes of people. The middle class is growing, incomes are rising, and cars are becoming more affordable. The experience in the U.S., Europe, and Japan has shown that car ownership levels accelerated rapidly when the price of the automobile became equivalent to the average annual income of the family (Morichi, 1992).

Table 2. Population and Population Densities

City	Total Land Area (km^2)	Population (000,000)			Population Density (persons / km^2)		
Year		1980	1990	1995	1980	1990	1995
Bangkok	1,565	4.75	7.09	8.45	3,035	4,530	5,399
Jakarta	650	5.99	9.21	11.23	9,215	14,169	17,277
Kuala Lumpur	243		1.25			5,140	
Manila	636	5.97	8.88	10.69	9,387	13,962	16,808
Singapore	626	2.41	2.72	2.85	3,850	4,350	4,552
Tokyo	597	8.35	8.16	7.96	13,986	13,668	13,333

Source: Megacity Management in the Asian and Pacific Region, Vol. 1; Asian Development Bank

Car ownership rates are shown in Table 3. A fairly consistent correlation between GNP per capita and annual rate of car ownership increase can be observed in the values.

Table 3. Car Ownership Rates and GNP per Capita

City/Country	1996 GNP/cap (US$)	Data Year	Car Ownership Rate (cars/000 pop)	Annual Rate of car ownership increase (%)
Bangkok[a]	3,075	1991	212	7.4
Jakarta[b]	1,134	1990	119	7.5
Kuala Lumpur[b]	4,465	1985	142	8.4
Manila[a]	1,166	1991	88	4.5
Singapore[a]	30,469	1991	202	1.8
Tokyo[a]	36,521	1991	386	3.9

Source: [a]MMUTIS Progress Report I (January 1997)
[b]T. Kidokoro & H. Kubota, Travel Characteristics and Modal Usage in Motorizing Southeast Asian Cities, Journal of the EASTS, Autumn 1997.

3.2 URBAN TRANSPORTATION CHARACTERISTICS

3.2.1 Modal Split

A high usage of urban public transportation can be generally said of developing countries. As motorization is yet to reach its maximum, there is still a considerable share of public transportation in the total person trips in urban areas. Table 4 shows the modal split in the study area.

Metro Manila has the highest level of public transportation patronage in the study area. This is partly due to the high availability of public modes provided by jeepneys, buses, and to a limited extent, the LRT. Second in public transport patronage is Singapore. This is explained by the presence of high quality public transportation (buses and MRT) accompanied by restraints on car ownership and use. Bangkok and Jakarta are similar in public transportation patronage level. Kuala Lumpur has the lowest share of public transport trips among the five cities.

3.2.2 Congestion

Indices of congestion are varied. Such indices include average travel time, volume of vehicles on the road per unit time, amount of time per unit time spent by vehicles traveling at or below a certain threshold speed. The following inner city average travel speeds have been observed for the study area: Jakarta (15 kph), Bangkok (9 kph), Manila (10 kph), Singapore (30 kph), and Tokyo (15 kph).

Table 4. Modal Shares for Motorized Person Trips

	Bangkok	Jakarta	Kuala Lumpur	Metro Manila	Singapore
Year of Data	1995[1]	1998[2]	1997[3]	1996[4]	1996[5]
Total No of person trips per day	16,600,000		8,200,000	17,500,000	7,254,902
Private Modes					
% Share	53.6 %	56.3 %	73.5 %	21.6 %	49 %
Cars	25.8 %	40.9 %	47.5 %	18.5 %	49 %
Motorcycles	22.1 %	15.4 %	26 %	0.7 %	
Other private mode	5.7 %			2.4 %	
Public Modes					
% Share	46.4 %	43.7 %	26.5 %	78.5 %	51 %
Commuter Rail	0.7 %	4.9 %	0.5 %	0.0 %	
Urban Rail	n.a.	n.a.		2.3 %	9.6 %
Bus	33.9 %	33 %	24.4 %	17.4 %	41.35 %
Other modes	4.2 %	5.8 %	1.6 %	52.5 %	
Taxi	7.6 %			6.2 %	
Remarks	in terms of person trips	in terms of pass-kms	in terms of person trips	in terms of person trips	in terms of person trips

3.2.3 Public Transportation

Public transportation plays a vital role meeting urban travel demand in Asian cities. Public transportation patronage varies in the region, with Metro Manila enjoying the highest level, followed by Singapore, Bangkok and Jakarta, and Kuala Lumpur. This sequence may be partly explained by the relative wealth of these cities (prior to the Asian financial crisis), with Kuala Lumpur leading the group, followed by Bangkok and Jakarta, and Metro Manila. Singapore is the most affluent among the five cities, but with very strict control on

[1] Report on Traffic and Transport for the 8th National Social & Development Plan, June 1996
[2] Strategic Urban Roads Infrastructure Project (SURIP), August 1998
[3] A Study on Integrated Urban Transportation Strategies for Environmental Improvement in Kuala Lumpur, March 1998
[4] Metro Manila's Transportation & Traffic Situation, MMUTIS, March 1998
[5] A World Class Land Transport System, January 1996

the ownership and use of private cars and the government's and private sector's strong resolve to promote public transportation, private car modal share has been held at bay.

Public transportation is as varied as the cities themselves. Various high to simple technology modes can be found in different cities. With widely varying characteristics such as investment costs, capacities, levels of service, and source of technology (local or foreign), these modes serve the diverse needs of urban dwellers.

With the exception of Japan, buses form the backbone of urban public transportation services in Asia. There are varying levels of public/private ownership of bus systems in the region, with Tokyo having 90% publicly owned bus industry, full private ownership for Metro Manila, Kuala Lumpur, and Singapore, and shared ownership for Bangkok and Jakarta.

For cities in some developing countries, there used to be bigger public sector involvement in bus operations (e.g. Manila and Jakarta). But companies were frequently observed to be saddled with poor management, operated by labor regulated by restrictive practices, constrained by inadequate financing policies, affected by poor maintenance of vehicles, and unable to provide adequate service frequencies and route networks. Public sector bus operations are generally inefficient and subsidized.

In Singapore, government involvement in public transport did not result in a loss of private ownership or subsidies. Improvements were achieved over several years by reorganizing 11 bus companies into 4, then 3, and ultimately 1 with the infusion of management skills and better enforcement of regulations. Now, Singapore has 2 privately owned bus companies enjoying healthy competition and profitable operations.

4. TG MODELING

4.1 Assumptions of TG Modeling

The choice of the appropriate transportation system for a city is dependent on the characteristics of that city. City size and demand density are parameters that define the suitability of a mode to a particular kind of city. It is possible to identify the domain of a mode, those ranges of travel demand density and city size where that mode is appropriate. If these parameters are represented in a cartesian coordinate system where the vertical axis is demand density and horizontal axis is size of city, the domain of a mode can be delineated accordingly. Superimposing the domains of the different modes on the cartesian plane show regions that are not covered by any domain. Such regions are called 'transportation gaps'.

The study assumes a simple urban form. It is assumed that trip demand is proportional to population density and for purposes of simplicity, it is assumed to be uniform throughout a city. In order to make the different modes comparable, it is assumed that all trips are made through one-meter wide equivalent of transportation facilities such as railways or roads and are linearly accumulated from right to left, where the city center is assumed to be located.

The two parameters defining the domain of a mode are demand density *a* (in terms of person per hour-km) and size of city *r* (in terms of the length of the transportation facility, in kms). The upper bound of the domain of a mode is the demand density *a(upper)* equivalent to the physical capacity of that mode. The physical capacity of trip demand is calculated as:

Physical capacity *a(upper)* = (Capacity of the mode per meter of right-of-way) / (size of city *r*) (1)

The lower bound is delineated by the demand density *a(lower)* that will result in break-even operations for public transportation modes. This is applicable to the public transportation modes which, under ideal conditions, should operate without financial deficit. This financial capacity of demand density is calculated by:

$$\text{Total cost} = \text{Total Revenue} \tag{2}$$

where total cost includes initial investment cost (construction and rolling stock), operating costs, and other pertinent costs. Total revenue includes farebox and other sources. Both total cost and total revenue are on a yearly basis; hence it is necessary to estimate the annual equivalents of the costs. Annual operating costs may be readily calculated. For initial investment costs, the annual equivalents are estimated using Capital Collection Method which distributes costs into annual amounts over a certain length of time:

$$M = P \{i\ (1+i)^n\} / \{(1+i)^n - 1\} \tag{3}$$

where *M* is the annual amount, *P* is the total amount of investment, *i* is the interest rate, and *n* is the number of years over which the total amount is distributed.

The resulting expression for total cost is in terms of *r*; that for total revenue is in terms of *r* and *a(lower)*. Therefore, the *a(lower)* for which there will be a minimum of break-even operations can be computed. This defines the lower bound of the domain. The chart below shows these operations.

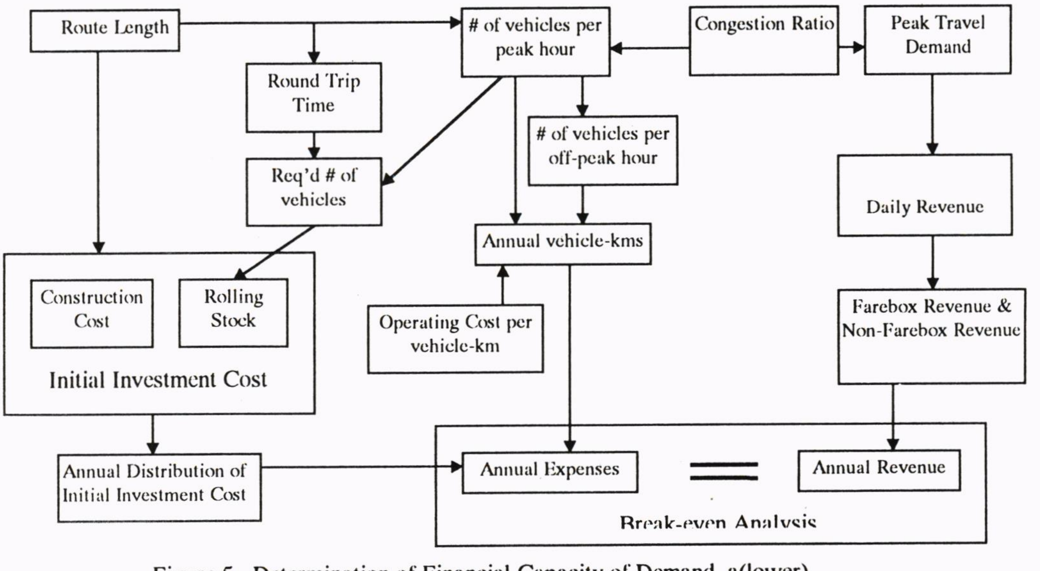

Figure 5. Determination of Financial Capacity of Demand, a(lower)

4.2 Policy Variables to be used in the Evaluation

The equations that represent the boundaries of the domain incorporate certain variables that represent policies that influence the performance of the modes. Different values of these policy variables are considered and their effect on the resulting domains and TGs are analyzed. Several cases are evaluated for each mode in order to simulate the changes on the domains that result from changing the policy variables.

Policy variables used in the study are interest rate (*i*) and operating subsidy (*SUB*) for LRT and bus modes, and interest rate (*i*) and congestion ratio (*CR*) for jeepney.

4.3 Modeling Results (for Metro Manila)

4.3.1 Domain for LRT

The LRT Line 1 of Manila is a 15-kilometer fully elevated urban railway. With an initial investment cost (construction and rolling stock) of 3.49 billion pesos (1.29 billion government equity and 2.2 billion foreign loans mostly from the government of Belgium), it opened in 1984 and runs in a north-south direction from Monumento to Baclaran. It is owned and operated by the Light Rail Transit Authority (LRTA), a government entity. A private company, the Metro, is contracted by the LRTA to manage the operations in exchange for a fixed management fee.

The following are the data and equations used in developing the domain of LRT for the present case (base case):

- operating speed, v = 30 kph
- individual car capacity = 374 persons
- # of cars per train, *form* = 2 cars per train
- # of trains per peak hour, *pn* = 25 trains per peak hour
- # of trains per off-peak hour, *opn* = 12 trains per off-peak hour
- round trip time, *prh* = (2 r / v) x 60 + 15 , where 15 minutes is the turn-around time at terminal or depot
- required # of trains, *tn* = prh / (60 / pn) x 1.10 x form = 3.67 r + 13.75 where reserve ratio of trains is 1.10
- required # of trains at peak hour, *ptn* = pn x 2 = 50
- required # of trains for off-peak time, *optn* = opn x (oh - 1) x 2 = 360
- yearly train-kms, yok = r {(270) (ptn + optn) + 95 (0.80) (ptn + optn)} = 141,940 r where in a year, 270 days have full operation and 95 days have 80% of operations.
- operating cost per train-km = 227.82 Pesos per train-km
- interest rate, i = 8%
- project life, n = 30 years
- fare = 10 Pesos flat rate

<u>*Physical Capacity Module:*</u>

a (upper) = capacity at peak hour for 1-meter wide right-of-way / r = (374) (2) (25) / 4 r, with LRT right-of-way equal to 4 meters.

a (upper) = $4.675 \times 10^3 / r$

Financial Capacity Module:

Total Annual Cost = (annual operating cost + annual component of initial investment cost + annual loan payments) (1 - SUB), where SUB is annual government subsidy

Total Annual Revenue:

$$\text{Revenue per hour, Rev} = \int_0^r 10\,a\,(2)\,dx = 20\,a\,r$$

where 10 is the flat fare per person; *a* is the demand density in person per hr-kms; 2 is for round trip; and dx is the incremental trip length in kms.
Revenue per day = (20 a r) / 0.25 = 80 a r
Revenue per year = (80 a r) (270) + (80 a r) (95) (0.80) = (27.68×10^3) a r

To get demand density for break-even operations:

Total Cost per year = Total Revenue per year

This will yield *a (lower)* as a function of r. The domain of LRT for the base case is as shown in Figure 6a.

Though it exists, the domain of LRT is small, with amounts of revenue and operating costs close to each other. Although LRT is operationally and technically successful, it has dismal financial performance due mainly to considerable foreign debt servicing. In layman's terms, the LRT is barely coping with the financial demands of its operations. Simulating the effects of changing the interest rates and government subsidy will be shown later.

4.3.2 Domain for Bus

The identification of bus' domain is similar to that of the LRT except for the fact that bus transportation does not require initial investment for carriageway construction. Average operating speed is 12 kph; bus capacity is 85 persons; peak hour headway is 1.5 minutes (40 buses per peak hour); off-peak headway is 3 minutes (20 buses per off-peak hour); operating hours per day is 17.5 hours; full operations are for 270 days a year and 80% of operations for 95 days a year; operating cost per bus-km is 4.71 pesos per bus-km; vehicle cost is 1,500,000 pesos; interest rate for vehicle loan is 11% for a period of 15 years; fare is 2 pesos for the first 4 kms and 0.415 pesos for each succeeding km; carriageway width is 4 meters; peak-hour revenue is ¼ of daily revenue. Setting up the expressions for *a (upper)* and *a (lower)* yields the following domain of bus for the base case as shown in Figure 6b.

The resulting domain confirms the reality of bus operations in Metro Manila. At present, bus operations are considered viable as evidenced by the high demand of more operators to enter the business. Despite the absence of government subsidy, private bus operations are generally financially viable. Inspite of tight financial situation, bus operations are coping well.

4.3.3 Domain for Jeepney

The jeepney is the major public transportation mode in Metro Manila accounting for 39.1% of all person trips (as opposed to bus' 14.9% and LRT's 2.3%) (MMUTIS, 1998). The following data are used in the delineation of the domain of jeepney. Average operating speed is 12 kph; jeepney capacity is 18 persons; peak hour headway is 1 minute (60 jeepneys per peak hour); off-peak headway is 5 minutes (12 jeepneys per off-peak hour); operating hours per day is 15 hours; full operations are for 270 days a year and 80% of operations for 95 days a year; operating cost per jeepney-km is 3.52 pesos per jeepney-km; vehicle cost is 150,000 pesos; interest rate for vehicle loan is 11% for a period of 5 years; fare is 2 pesos for the first 4 kms and 0.37 pesos for each succeeding km; carriageway width is 4 meters; peak-hour revenue is ¼ of daily revenue. The domain of the jeepney is shown in Figure 6c.

An observation similar to that for bus can be made for jeepneys: operators are able to cope and they enjoy viable operations, although jeepney's domain is smaller than the bus'. However, rising costs of spare parts and fuel are endangering the viability of jeepney operations. In a study on sustainability of jeepney business in Metro Manila (Nemoto et. al., 1996), a deterioration in the viability of jeepney operations is observed. From a 1.0:1.7 ratio of fuel cost to driver's earnings in 1985, a lower ratio of 1.0:1.4 has been observed in 1996. Policy variables (loan interest rate and allowable congestion ratio) will be considered in the simulation.

4.3.4 Domain for Car

No break-even analysis is made in defining the domain of the car since it is not income-generating. The upper bound is the physical capacity of demand and the lower bound is the x and y axes. The calculations assume a highway capacity of 1,200 vehicles per lane per hour; lane width is 4 meters; average car occupancy is 2.5 persons per vehicle. The domain for car is shown in Figure 7.

4.3.5 Domain for Walking

The analysis assumes the following values: average capacity of pedestrian facilities in the Philippines is 75 persons per meter per minute; average walking speed at maximum flow is 41.62 meters per minute; maximum tolerable walking time is around 10 minutes due to climate and cultural factors (Gerilla, 1995). This translates to a maximum walking distance of around 400 meters.

The domains of all modes are superimposed to show the resulting transportation gaps. This is presented in Figure 7.

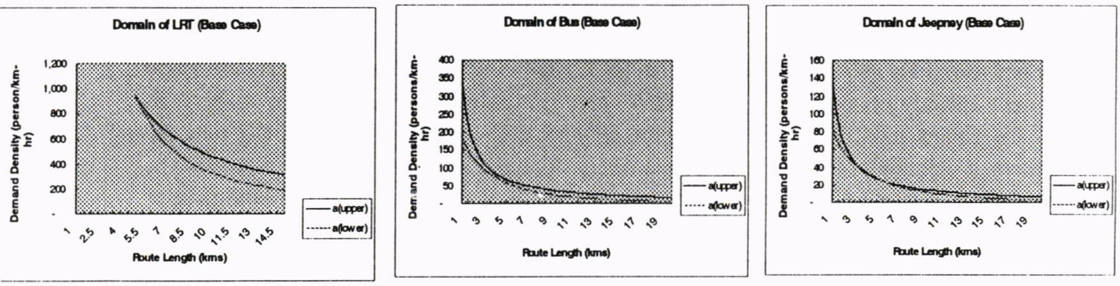

Figure 6. Domains for LRT, Bus, & Jeepney (Base Case)

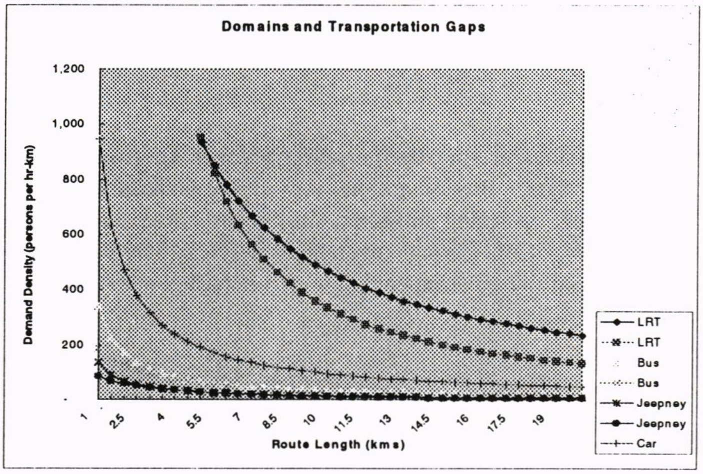

Figure 7. Superimposed Domains and Transportation Gaps

Transportation gaps are found in the space between the domains of the LRT and the private car and that between the domains of bus and jeepney. As expected, the positions of the domains of the LRT, bus, and jeepney are positioned in the manner shown in the figure because of their physical capacities and financial requirements. There is a big TG between LRT and the other public transportation modes, showing the contrast between high-technology and lower-technology modes. The TG between bus and jeepney may be served by other modes of transport that are not yet included in the present analysis. An example is the Tamaraw FX (airconditioned 10-passenger capacity Asian Utility Vehicles plying fixed routes currently being considered by the government for franchising).

4.3.6 Policy Simulation and Resulting TGs

The following policy variables were used in simulating the new domains and resulting TGs.

Mode	Base Case	Case 1	Case 2	Case 3	Case 4
LRT	i = 8% SUB = 0	i = 3% SUB = 0	i = 5% SUB = 0	i = 8% SUB = 0.25	i = 8% SUB = 0.50
Bus	i = 11% SUB = 0	i = 3% SUB = 0	i = 8% SUB = 0	i = 11% SUB = 0.25	
Jeepney	i = 11% CR = 1.0	i = 3% CR = 1.0	i = 8% CR = 1.0	i = 11% CR = 1.25	

where i is loan interest rate, SUB is government subsidy on total operating costs, and CR is congestion ratio for jeepneys.

LRT

Two policy variables are considered for the LRT. Different values of interest rate *i* and government subsidy on operating costs *SUB* are used. In the base case, average *i* is around 8% (loans mostly from the Belgian government) and subsidy from the national government is minimal. In the early stages of its operations, the largest expense was the payment of interest on loans, almost amounting to 40% of total costs. Considering softer loans such as those with lower interest rates from international financing agencies (e.g. OECF with 3%), the resulting domain slightly increases. Considering higher government subsidies (25% and 50% of total operating costs) yields larger increases in the domain. Simulating the combined effects of lower *i* and higher *SUB* is expected to result in larger expansion of LRT's domain. Figure 8 shows this policy simulation.

Bus

Acquisition of rolling stock are mostly through loans with an average interest rate of 11% over a period of 15 years. Bus operations are wholly undertaken by the private sector without any government operating subsidies. In the base case, bus operations are already shown to be profitable. Considering lower interest rates (3% and 8%) or introducing operating subsidies from the government (25% of operating costs) will expand the domain of bus. See Figure 9.

Jeepney

Like bus operations, jeepney operations are viable even in the base case. Bus the domain is not as large as for buses. Different values of interest rates on purchase of vehicles (3% and 8%) are considered resulting in expansion of the domain. Considering a higher allowable congestion ratio (1.25 compared to the base case 1.0) , however, produces bigger results. This translates to about 4 passengers in excess of the seating capacity. Although this may possibly compromise traffic safety, officially allowing this will improve the financial viability of jeepney operations. The policy simulation is depicted in Figure 10.

Considering the different values of the policy variables increases the domains of the public transportation modes. With more favorable conditions provided by lower interest rates, available operating subsidies (favorable on the part of the operators, assuming no negative effect on their operating efficiencies), and higher allowable congestion ratio for jeepneys, the resulting TGs are expected to decrease. This means that public transportation will be able to better cope with the financial demands of operations.

5. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

This study presents the different characteristics of urban transportation in five Asian cities. With economic uncertainty prevailing in the region, it is important that the different transport modes operate efficiently. It is necessary to find the most suitable transportation system considering the characteristics of a city.

The study also presents the concept of transportation gap. Using actual operational and financial data for Metro Manila, the performance domains and resulting transportation gaps

(TG) are identified. These TG models incorporate policy variables that can be considered for simulation. It was shown that more favorable values of interest rates, availability of operating subsidies from the government, and allowing higher congestion ratio for public transportation can expand the domains and thereby decrease the transportation gaps.

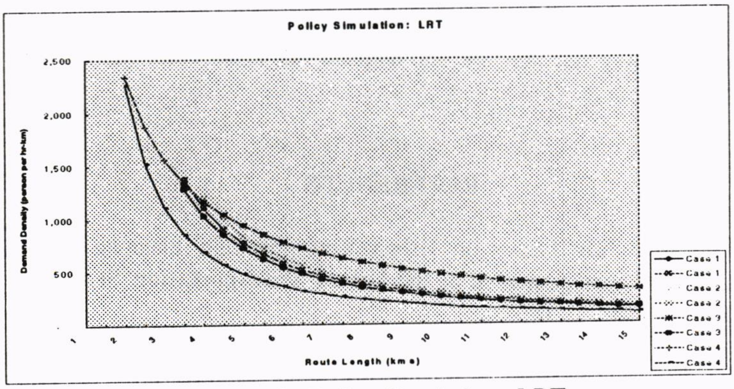

Figure 8. Policy Simulation: LRT

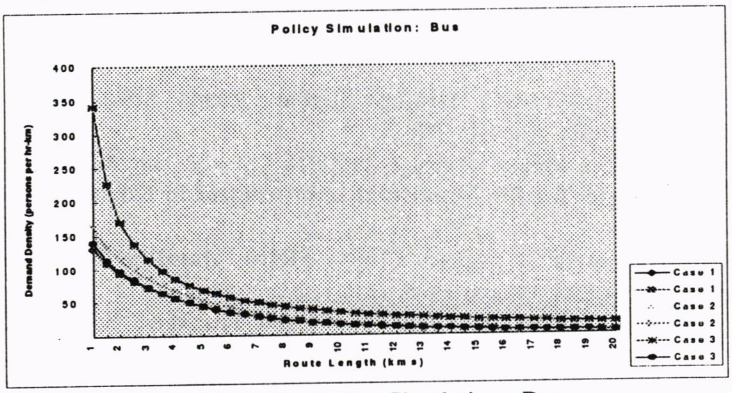

Figure 9. Policy Simulation: Bus

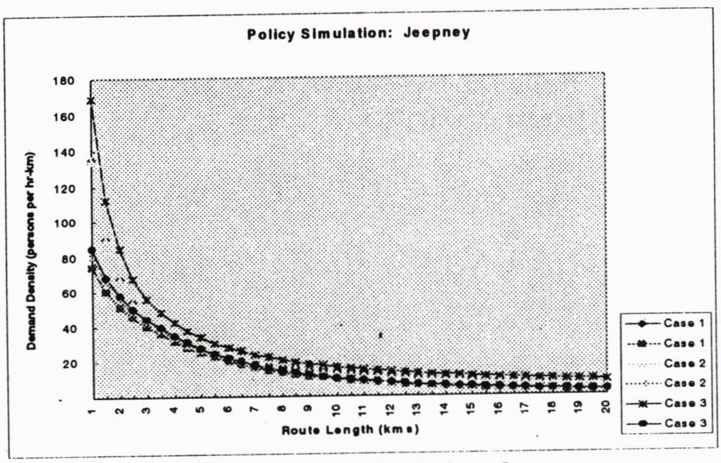

Figure 10. Policy Simulation: Jeepney

This study has focused only on the supply side analysis of urban transportation of Metro Manila assuming uniform demand distribution. Although this assumption may be sufficient for the purposes of the present study, it may be too simplifying so as to compromise the analysis results for the case of Metro Manila. Hence, more realistic assumptions on demand distribution are warranted to improve the analysis and more closely model reality. Forthcoming stages of the study will include other demand distribution assumptions, new policy variables for supply side analysis, and demand side analysis for Metro Manila and the other cities in the study area.

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