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University of California at Berkeley

PARATRANSIT IN SOUTHEAST ASIA: A Market Response to Poor Roads?*

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Southeast Asia's paratransit sector has become a vital source of mobility in many cities. Run by private operators, generally under free market conditions, paratransit vehicles maneuver into areas that standard buses cannot serve and provide frequent door-to-door service, at a profit. Yet despite past successes, pressure is mounting to greatly restrict or even ban paratransit vehicles from many cities, replacing becaks, bajajs, tuktuks, microbuses, minibuses, and jeepneys with large buses operated by public monopolies. While it is well known that paratransit provides low performance services tailored to what poor people can pay, an often overlooked benefit is that it compensates for the inadequacies of many roads in Southeast Asian cities. This paper empirically tests the extent to which mixes of paratransit fleets and services have evolved so as to adapt to the low capacity, poorly interconnected road systems in this part of the world. Using data for eight of Southeast Asia's largest cities, it is found that the greatest variety of paratransit modes, both in terms of types and seating capacities, generally exists in the places with the least amount of road capacity per capita and a poor road hierarchy. The paper concludes that any retrenchment in paratransit's role in Southeast Asian cities should be governed by market conditions rather than government fiat.

1. Introduction

Traffic congestion is as severe in the large cities of Southeast Asia as anywhere in the world. Besides wasting time, money, and resources, unbridled traffic is a major cause of fatalities, particularly among youths, and the chief source of air pollution in all major Southeast Asian metropolises (Yeung, 1976; Rimmer, 1986). Unless reversed, traffic congestion could stymie future economic growth, particularly in large primate cities, the places that have historically been the engines behind national expansion and industrialization.

Throughout Southeast Asia, urban traffic congestion has steadily worsened over the past decade as the motorized vehicle population has far outpaced road building efforts. In Jakarta, Bangkok, and Manila, vehicle registrations grew at an annual rate of between 10 and 15 percent throughout the 1980's, whereas only a few kilometers of roads were typically added in these cities each year over the same period (Spencer and Madhavan, 1989). Less than 10 percent of total urban space in these three cities, moreover, is devoted to roadways. By comparison, roads make up 22 percent of the land area in London and 24 percent in New York City (Sinsap, et al., 1988). The problem is not just

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a lack of capacity, but also a lack of any functional or effective road hierarchy. Just as rivers rely on good tributaries and the body depends on unobstructed arteries and capillaries, there must be a well-functioning network of local streets that interconnect with collectors and arterials for traffic to circulate efficiently. In many Southeast Asian cities, few good distributor roads are available. What would be considered local streets in the developed world are forced to function as collectors in the third world. Yet most local streets are too narrow and under-maintained to handle the traffic being funneled onto them. While converting narrow streets to one-way operation has sometimes helped, trip-making often becomes circuitous as a result.

Another distinctive feature of the urban transportation systems of many Southeast Asian cities is the dominance of the "free enterprise" or "informal" transport sector. For a host of reasons — e.g., few households own vehicles, market entry is loosely regulated, public transit is often overburdened, and huge labor surpluses exit — a dynamic and wide-ranging paratransit sector has evolved in cities like Jakarta and Manila. Paratransit takes many names, shapes, and forms in Southeast Asia, but is generally characterized by fleets of three-wheelers, jitneys, collective taxis, and minibuses that cruise the streets for customers, providing either door-to-door or mainline service. Ranging from human-powered rickshaws (becaks, tricycles) and three-wheel motorized scooters (bajaks, tuk-tuks) to small buses (bemos, opelets, mikrolets), the paratransit sector offers a wide range of services in terms of seating capacity, speeds, geographic coverage, levels of comfort, and fares (Roth, 1988; Chujoh, 1989). Some vehicles serve local trips of two to three blocks, others serve more intermediate distance travel, while still others cover entire regions. Because many neighborhood streets are so narrow and poorly maintained, paratransit also penetrates areas that buses and larger vehicles can not. Small vehicles offer other advantages over buses: they take less time to load and unload, they stop less frequently, and run on shorter headways (Roschlau, 1989; Chujoh, 1989). Driven by the profit motive, paratransit operators aggressively seek out new and expanding markets, innovating when and where necessary. They generally provide low performance services, but at a cheap price. Additionally, the informal transport sector has also become an important source of urban employment, particularly for young males who have temporarily migrated from the rural countryside (Walters, 1979; Silcock, 1981; Kartodirdjo, 1981).

2. Laissez Fair or Regulation?

The informal paratransit sector expanded throughout Southeast Asian cities during the post-WWII period. By 1975, there were an estimated 140,000 paratransit vehicles (bajaks, helicaks, bemos, becaks) in Jakarta and 90,000 in Surabaya, Indonesia (Jacobs and Fouracre, 1974). As their numbers swelled and they began to compete for roadspace, traffic conditions began deteriorating in these cities. Since some vehicles are human propelled and most others have low power-to-weight ratios, paratransit vehicles are universally slow. Private motorist, commercial trucks, and public buses have thus found it difficult to co-exist with them. Paratransit operators are also frequently criticized for reckless driving, blocking lanes to load and unload passengers, overloading and operating unsafe vehicles, and excessive cruising for customers (Jacobs and Fouracre, 1974; Mogridge, 1983; Kirby, et al., 1986A, 1986B). Many foreign consultants have also argued

that paratransit modes have hampered the development of more modern transportation systems and technologies (Rimmer and Dick, 1980; Mogridge, 1983). For these and other reasons, pressure has been mounting to restrict and, in some cases, even phase out paratransit operations. This whittling away process seems to have gained a momentum of its own — Bangkok abolished all pedicabs (*samlor*) in 1962 and a decade later merged 25 private bus franchises into a regional bus authority; Jakarta stopped issuing licenses for human-powered *becaks* in 1972 and banned them from the city limits altogether in 1990; Manila has restricted jeepneys (12-14 passenger converted army jeeps) to a limited number of streets and cut back on licenses to the point where illegal operations now outnumber legal ones; Singapore eliminated its pirate taxis and over the past two decades consolidated eleven private Chinese bus companies into a single state-controlled enterprise (Rimmer and Dick, 1980; Krynetr, 1988).

Still, for the most part, most bans so far have been limited to pedicabs and other human-powered tricycles, a mode that few would disagree is ill-suited for most streets of rapidly modernizing cities. Those motorized vehicles that have been outlawed, such as the *helicak* in Jakarta, have been done so mainly for safety reasons. Most remaining motorized three-wheelers, such as Jakarta's *bajas*, have been restricted to specific zones. Some critics warn, however, that the handwriting is on the wall and that the paratransit sector's days in Southeast Asia are numbered (Rimmer and Dick, 1980; Roth, 1988; Roschlau, 1989). These same critics charge that the movement to abolish the paratransit sector is driven more by politics than economic reasoning. Among the reasons given are: foreign consultants and other "hired guns", many of whom only take taxis when in these cities and don't appreciate how important paratransit is to the urban poor, are culturally biased against paratransit; foreign lenders are seeking to export modern transport technologies to developing regions, a form of technological imperialism; and in the drive toward modernization, particularly in image-conscious national capitals, paratransit is viewed as an inferior, obsolete mode (Thomson, 1977; White, 1981; Dick and Rimmer, 1986; Rimmer, 1986). Whatever the motivations, excessive regulation of paratransit could have serious repercussions, not only in terms of the efficiency of urban transportation services but with regards to equity as well. The few economic studies that have been conducted have generally found paratransit services to be an economic asset, eliminating the need for government subsidies and taking some of the peak period burdens off of public transit systems. For example, Manila's 60,000 jeepneys, a mainstay of the city's transportation system, carry nearly 50 percent of all peak hour passenger trips. Research has shown that Manila's jeepneys cost 16 percent less per seat mile than standard buses and generally provide a higher quality service (e.g., greater reliability, shorter waits) at a lower fare (Roth and Wynne, 1982). Most jeepney owner-operators ply their trade along corridors where short, multi-destinational trips are made, the very trips that are most costly for public transit to serve. Jeepney operators, moreover, have historically been the last to petition for fare increases. Almost all turn a profit where public transit authorities are unable to.

One irony of this situation is that at the same time many Southeast Asian cities are starting to cut back on the paratransit sector and substitute large public buses for small private vehicles, many first world cities are contemplating opening up markets to the

private sector to foster greater competition and service innovation. Apparently, third world cities want their transport sector to look more like that of first world cities and first world cities want vice-versa. Equally puzzling is why the paratransit sector is being primed for regulation at a time when privatization and self-reliance are being promoted in other sectors of Southeast Asian economies (Roschlau, 1989). Increasingly, public officials in this part of the world are grappling with the question by how much, if at all, market entry, price levels, and service practices should be regulated within Southeast Asia's paratransit sector.

It is against this backdrop that important policy decisions will be made in coming years on the fate of three-wheelers, bemos, jeepneys, and other small-scale vehicles in Southeast Asian cities. Clearly, better information is needed to guide future choices. This paper seeks to clarify the contributions of paratransit toward making the road systems of Southeast Asian cities function better. Specifically, it is argued that the paratransit forms that have evolved to date are largely market-driven responses to the current deficiencies of the road networks of Southeast Asian cities. Paratransit, I believe, helps compensate for the lack of capacity and poorly developed road hierarchies of these cities. The paratransit sector offers a balance of travel speeds and seating capacities that are adjusted to the physical streetscapes and also provides services suited to the low incomes and relatively low value of time among most poor people in these places. Thus, over the years, unencumbered by government regulations, I will argue, paratransit has evolved as a modal adaptation to the deficiencies of road systems in Southeast Asian cities.

Anecdotally, one can find situations where this proposition seems to be borne out. Take Jakarta, for instance. Because rivers originating in the southern mountain range flow north toward the city, Jakarta's north-south streets are well developed, paralleling the rivers on firm soil beds. Most east-west streets, on the other hand, have an undulating profile, are narrow, and generally lack continuity. Bottlenecks are common at east-west bridge crossings. Over the years, a number of paratransit modes, like bajajs, bemos, and mikrolets, have plied their trade over east-west roads. Most major north-south roads, on the other hand, have been banned to all but private motorists and public buses. Thus, in Jakarta, paratransit operations have been leaned upon to increase the passenger throughput of deficient east-west thoroughfares. Ostensibly, they have evolved in number and composition to serve these under-capacity, poorly connected corridors — that is, they have functioned as a modal response to the inadequacies of Jakarta's road system.

While illustrious, such tales are usually dismissed as mere anecdotes. This paper subjects this research hypothesis to closer scrutiny by using aggregate data on the composition of transportation modes and road systems for eight of Southeast Asia's largest cities. As such, it is a supply-side analysis, seeking to explore how strongly various indicators on mode diversity and composition are correlated to various indicators of road deficiency. Simple descriptive statistics and correlation measures are used in this pursuit. The paper concludes with suggestions on linking future paratransit operations to programs aimed at expanding and upgrading roads and improving overall economic conditions.

3. Research Approach

To test the hypotheses posed, supply-side data were compiled on the modal and road-way characteristics of the following Southeast Asian cities: in Indonesia, Jakarta, Surabaya, Medan, and Bandung; and elsewhere, Bangkok (Thailand), Manila (the Philippines), Kuala Lumpur (Malaysia), and Singapore (see Figure 1). These are among the densest, most populated cities in Southeast Asia, each having over 1.5 million inhabitants. Moreover, these cities include primate centers and national capitals of the largest and economically most advanced non-aligned nations of the region. For six of the eight cities, data were available for multiple points in time. Pooling cross-sectional data over time, 16 cases were available for the analysis.

Data were gathered from a variety of sources, including annual statistics made available by municipal and regional traffic departments, consulting studies, published articles, and field interviews. Official statistics were used as much as possible. Data sources were triangulated to check for consistency. Where inconsistencies existed, estimates provided by knowledgeable local officials were used.

In testing the research hypotheses, two basic measures of modal diversity and three indicators of road system quality were relied upon. Modal diversity was gauged by :

- (1) **Mode Type Diversity Index:** Among the various modal classes for each city, a coefficient of variation (standard deviation divided by mean) was measured based on the number of vehicles in each class. High values indicated considerable variation in basic types of passenger vehicles.

Figure 1.
Eight Southeast Asian Cities Studied

- (2) **Mode Capacity Diversity Index:** The number of vehicles was weighted by average seating capacity of vehicles in each class. From this weighted figure, the coefficient of variation was then computed. High values indicated considerable diversity in the passenger carrying capacity among classes of vehicles.

These measures were matched against the following indicators of road system quality:

- (3) **Road Kilometers per 100,000 Population:** The number of lineal kilometers of paved roads within each metropolitan area per 100,000 residents. High values indicated relatively high levels of capacity.
- (4) **Road Hierarchy Index:** Among the various classes of roads, a coefficient of variation statistic was measured based on the lineal kilometers of roads within each class, with classes generally defined as arterials, collectors, and local streets. High values indicated considerable variation in road types, generally to be expected in a well-developed road system.
- (5) **Road Capacity Variety Index:** The kilometers of roads in each class were weighted by an ordinal number to account for the higher carrying capacity of higher order roads. The coefficient of variation was then computed from the weighted figures. High values indicated considerable variation in road capacity (suggesting an imbalanced road hierarchy) whereas low values indicated that the overall capacities of road classes were in balance. (In general, this index should be low since, computationally, the kilometers of less numerous arterials are upweighted and those of more prevalent local streets are downweighted. Adjusting by weights which reflect the vehicular capacities of each class of road, the coefficient of variation should be small for a well-developed road system).

Statistically, this research hypothesizes that the two modal diversity indexes should be negatively related to the third and fourth indices and positively associated with the last one. To the extent this is true, one can surmise that paratransit services thrive in settings where road capacity is limited and the road hierarchy is underdeveloped. To the extent that the informal transport sector has been given a free reign, as in most Southeast Asian cities, one can infer that paratransit services have evolved as a market response to the deficient roads systems in place. The remainder of this paper tests the extent to which these propositions hold.

4. Background Characteristics of Cities Studied

Summary statistics on population, densities, and road facilities are shown for the eight case study cities in Table 1 for different time points. From the latest time point for each city, which in most cases was 1988, the average population was 4.27 million and the average density was over 10,000 persons per square mile. Jakarta is the most populated city in Southeast Asia and its neighbor to the south, Bandung, with over 1.6 million residents living in an 81 square kilometer area, is one of the densest. With the exception of more modern and affluent Singapore, most Southeast Asian cities have few kilometers of roads relative to their populations. The three Indonesian cities of Surabaya, Medan,

and Bandung only have between 20 to 35 lineal kilometers of paved roads for every 100,000 residents, three to four times less than in Singapore. In many ways, as a fairly prosperous and rapidly modernizing island-state, Singapore differs from the other seven cities, resembling many first-world cities more than third-world ones. Still, since ethnically, culturally, and geo-politically it is similar to the other places studied, and equally important, mass transit plays a dominant role in its transportation system, Singapore was retained in the analysis.

One of the primary reasons behind worsening urban conditions in general and traffic congestion, specifically, in all of these cities has been the meteoric growth in automobile ownership. Most Southeast Asian cities, originally built for foot and hoof travel, were never designed or planned to handle so many autos, trucks, and buses. Between 1957 and 1969, the car population increased threefold in Singapore and sixfold in Bangkok (Yeung, 1976). From 1972 to 1987, Bandung's count of passenger cars tripled; in Jakarta, Manila and Medan, car populations more than doubled during the 1980's (Spencer and Madhavan, 1989).

Despite explosive growth in the car population, the paratransit sector of most of these cities remains strong. In Manila and Jakarta, over 60 percent of all mass transit trips are served by medium- and small-sized vehicles (Chujoh, 1989; Halcrow and Fox Associates, 1982). The different types of paratransit fleets operating in each city are listed in the Appendix. Overall, there are five classes of mass transport vehicles among these cities,

Table 1.
Background Characteristics on Population, Density, and Road
Characteristics of Eight Southeast Asian Cities

Metro Area	Year	Population (millions)	Land Area (km ²)	Density Pop/km ²	Lineal Road ksm	Lineal Road kms/ 100,000 Pop	Lineal Road ksm/ km ² Area	Motor Vehicles (1,000s)	Lineal Road kms/1,000 Vehicles
Bandung	1972	1.23	76	16,184	441	35.9	5.8	143.6	3.1
	1980	1.35	80	16,875	516	38.2	6.5	225.2	2.3
	1987	1.60	81	19,753	562	35.1	6.9	314.7	1.8
Bangkok	1983	6.40	500	12,800	2,659	41.5	5.3	805.3	3.3
	1988	7.32	810	9,037	2,812	38.4	3.5	1,097.3	2.6
Jakarta	1980	6.58	656	10,030	2,828	43.0	4.3	682.1	4.1
	1988	7.83	656	11,936	3,583	45.8	5.5	1,174.3	3.1
Kuala Lumpur	1985	1.65	244	6,762	706	42.8	2.9	281.1	2.5
Manila	1982	6.20	636	9,748	2,738	44.2	4.3	355.8	7.7
	1988	7.65	636	12,028	2,937	38.4	4.6	521.8	5.6
Medan	1988	2.30	280	8,214	630	27.4	2.3	229.5	2.7
Singapore	1972	2.12	620	3,419	1,475	69.6	2.4	207.9	7.1
	1982	2.39	620	3,855	2,389	100.0	3.9	334.1	7.2
	1987	2.60	620	4,194	2,844	109.4	4.6	1,628.9	1.7
Surabaya	1976	2.28	292	7,808	598	26.2	2.0	144.6	4.1
	1988	3.18	316	10,063	658	20.7	2.1	384.8	1.7

Table 2.
Classes of Mass Transport Vehicles in Southeast Asian Cities

Class:	Seating Capacity Range:	Cities:	Types of Vehicles:
I.	24 – 86 passengers	Jakarta, Bangkok, Manila, Surabaya, Singapore, Medan, Bandung, Kuala Lumpur	Stage buses, double-deckers
II.	12 – 24 passengers	Jakarta Manila Bangkok Kuala Lumpur	Minibus, mikrolet Jeepney Minibus, silor Minibus
III.	6 – 12 passengers	Jakarta Surabaya, Medan Bandung	Opelet, bemo, mebea, mobet Bemo Kolt, bemo, minicar
IV.	2 – 6 passengers	Jakarta Bangkok Manila Medan	Bajaj, minicar, helicak Tuk-tuk, samlor Motor tricycle Motor becak
V.	1 – 4 passengers (non-motorized)	Jakarta, Medan Manila Singapore, Kuala Lumpur	Becak Calesa, tricycle Trishaw

summarized in Table 2. Starting with those vehicles with the most seating capacities, Class I is made up of both standard stage buses and double-decker buses, operated by both public and private enterprises. Class II vehicles consist of minibuses, designed to carry intermediate loads of 12 to 24 riders. Included here are Manila's jeepneys, Jakarta's Mikrolets, and Bandung's Daihatsu Kolt. The third class is made up mainly of microbuses — four-wheeled van-size vehicles that can seat 6 to 12 passengers (e.g., Jakarta's opelets and Medan and Surabaya's bemos). Class IV vehicles are motorized three-wheelers, each serving 2 to 4 passengers, such as Bangkok's Samlors and Tuk-tuks, Manila's motorized tricycles, and Jakarta's ubiquitous bajes. A final class consists of human-powered three-wheel and horse-powered four-wheel vehicles — e.g., Medan's becaks, Manila's colorful horse carts (calesa), and Singapore's trishaws. Since most of these non-motorized modes have already been banned or soon will be, combined with the fact that statistics on their numbers are unavailable or unreliable, this fifth class is excluded from the analyses.

Perhaps more than anywhere, Jakarta has an usually rich variety of passenger transport modes — from double-decker city buses to human-pedaled becaks, and most everything in between. With its large population base, large numbers of poor residents, loosely regulated paratransit market, and steady stream of unemployed rural in-migrants, Jakarta's paratransit sector continues to thrive, with well over 50,000 privately operated vehicles cruising the streets each day. In contrast, the paratransit sectors of Singapore and Kuala Lumpur have been reigned in through a combination of regulations, public

takeovers, and increased car ownership. In Kuala Lumpur, some 400 privately owned and operated minibuses are the sole paratransit survivor, still serving over 35 percent of motorized trips within the core area (Chua, 1983; Roth and Wynne, 1982). In Singapore, rickshaws and three-wheelers have been wholly replaced by an intricate web of stage and double-decker buses and a new regional heavy rail system.

In all eight cities, past consulting reports have specifically mentioned the conflict between paratransit modes and other motorized traffic as a major source of congestion (Wilbur Smith and Associates, 1974; Kocks, F.H., 1975; JAICA, 1985, 1986). Other factors that have been blamed include: too many narrow, poorly maintained roads; piecemeal road development; lack of road connectivity and excessive deadends, such as the fishbone road layout (Soi roads) of Bangkok; oversupply of curbside kiosks and hawkers, resulting in the spillover of pedestrians and activities into streets; insufficient off-street parking; lack of land use controls, resulting in the poor location of many traffic generating developments; and minimal enforcement of traffic laws (Jacobs and Fouracre, 1974; Kirby et al., 1986A, 1986B; Rimmer and Dick, 1980; Silcock, 1981).

5. Relationship Between Modal Diversity and Road Deficiencies

5.1 Estimating Indicators

Computations for the various indicators of modal diversity and road deficiency used in testing the research hypotheses are summarized in the Appendix. Before discussing the results, several caveats are in order. First, as mentioned above, only motorized forms of passenger transport were examined; trucks and other goods movement carriers as well as pedicabs, horsecarts, and other non-motorized modes were ignored. Second, modes and roads were examined solely on the supply-side rather than with respect to actual passenger demand levels. Since this analysis is centrally concerned with how modal compositions appear to adjust to road supplies, this focus is appropriate; in general, the same relationships should hold since under free market conditions, supply should respond to demand and vice-versa. Third, care was taken to ensure that the number of modal categories truly distinguished fundamental differences in classes of vehicles. In general, as the number of classes increases, measures of variation will likewise increase. In the case of Jakarta, for instance, municipal statistics separate out the number of minicars, helicaks, and super helicaks. Since all motorized three-wheelers are designed for one to two passengers, these three were combined and treated as one class. If treated separately, indicators of modal diversity would have increased for Jakarta.

Perhaps the most difficult measurement problem was with respect to road classifications. In general, little consistency was found in how municipalities classify roads. Bandung classifies them according to the width of facilities, with everything over 10 meters classified as arterials, roads 8 to 10 meters wide called collectors, and all other passageways defined as local streets. Other local traffic engineering departments rely upon subjective criteria to classify roads. In this analysis, locally designated classifications were used. In general, it appeared that most local offices classified many streets that were actually designed for local traffic as distributors and, in some cases, even main arterials. Thus, in a way, some of the classifications appear to be based more on demand

levels than actual supply characteristics. Overall, a weakness of the road diversity indices is that they are based on local definitions as opposed to the actual performance of the roads or any set of objective criteria.

The top half of each table in the Appendix presents the computations used in deriving the two modal indices: (1) *mode type diversity index* and (2) *mode capacity diversity index*. The first is the coefficient of variation for the number of vehicles in each class. All cities had vehicle classes of passenger cars, taxis, motorcycles, and buses. Among the remaining modes, the share of vehicles under each transport class varied considerably. As with the other indices, the coefficient of variation was used to gauge diversity since it controls for the measurement scales by dividing the standard deviation by the arithmetic mean.

The second indicator, the mode capacity diversity index, adjusts the number of vehicles in each class by the average passenger capacity of each mode. Midpoint capacity values were used for each class; in general, the vehicle capacity of each class was consistent across the eight cities, though there were several exceptions based on the unique nature of vehicles in certain places (e.g., Bangkok's samlors). The mode capacity diversity index equals the coefficient of variation for the total capacity column of each table in the Appendix.

Computations for two of the road quality indicators are shown in the bottom half of each table in the Appendix. Taking the coefficient of variation for the lineal kilometers in each road category produced the *road hierarchy index*. Five of the eight cities had three classes of roads, generally following the arterial-collector-local schema; Bangkok, Kuala Lumpur, and Singapore differentiated their roads more finely, including four classes. The calculated road hierarchy index for each city is represented by the coefficient of variation for the road kilometer column. In general, low values represent a lack of hierarchy.

Lastly, adjusting the preceding index by an ordinal rating of the hierarchal standing of each class yielded an index of road variety. The coefficient of variation for this index produced a *road capacity variety index*. Ordinal weights were used as a second-best approach because actual information on lane capacity was unavailable. In general, arterials received a weight of 5, collectors a weight of 3, and local streets a weight of 1 to establish a functional hierarchy. A low road capacity index suggests that local streets, collectors, and arterials have comparable capacity in total (even though local streets tend to outnumber all others in total kilometers), generally a sign of a well-balanced road hierarchy (Pignataro, 1973; Gennaoui, 1986).

5.2 Summary of Indicators

Table 3 summarizes the scores for the various mode and road indicators for each city (and for multiple time points). A comparison of index scores among cities suggests that the research hypotheses are borne out. Manila, for instance, scores high in terms of modal variety. It also has the lowest marks for road hierarchy, suggesting the existence of a poorly integrated road system. Singapore, on the other hand, presents the opposite picture. With virtually all paratransit services replaced by conventional and double-decker buses, it scores low with regard to variety of mode types and capacities. How-

Table 3.
Summary of Modal Diversity and Road Quality Indicators

Metro Area	year	Mode Indexes		Road Indexes			Comments
		Mode Type ¹	Mode Capacity ²	Road Kms per 100,000 Population ³	Hierarchy ⁴	Variety ⁵	
Bandung	1972	1.93	1.37	35.9	0.81	0.32	Moderate modal variety, though diminishing over time. Good road hierarchy and best balance of road capacity.
	1980	1.70	1.19	38.2	0.77	0.31	
	1987	1.69	1.08	35.1	0.72	0.35	
Bangkok	1983	1.32	1.27	41.5	0.98	0.50	Relatively low modal variety and strong road hierarchy.
	1988	1.33	1.32	38.4	0.99	0.51	
Jakarta	1980	2.12	1.74	43.0	0.23	0.54	High modal variety and fairly weak road hierarchy. Also, capacity imbalance.
	1988	1.75	1.47	45.8	0.32	0.56	
Kuala Lumpur	1985	1.17	1.20	42.8	0.38	0.63	Lowest modal variety. Fairly high road capacity per capita, though weak hierarchy.
Manila	1982	1.57	1.24	44.2	0.12	0.47	High variety in mode types and Weak road hierarchy and road capacity imbalance.
	1988	1.77	1.51	38.4	0.12	0.47	
Medan	1988	3.27	2.18	27.4	0.51	0.45	High modal variety. Moderate road hierarchy.
Singapore	1972	0.97	0.80	69.6	1.02	0.41	Fairly low variety in mode types and capacity. Best developed road hierarchy.
	1982	1.14	0.97	100.0	0.99	0.42	
	1987	1.21	1.06	109.4	0.99	0.42	
Surabaya	1976	1.53	1.17	26.2	0.21	0.41	Considerable modal variety. Lowest road capacity per capita.
	1988	1.84	1.27	20.7	0.43	0.47	

Notes:

1. High value indicates high variety of mode types.
2. High value indicates high variety of mode capacities.
3. High value indicates large amounts of road capacity relative to population size.
4. High value suggests considerable differentiation of road types (i.e., good hierarchy).
5. Low value suggests considerable balance of road capacity among types (i.e., balanced hierarchy).

ever, its road indices indicate that it has the most capacity per capita and the best developed road hierarchy among cities. A close inspection of the table suggests that these kinds of relationships hold for other cities as well. Perhaps the one exception is Kuala Lumpur, which has a low level of modal variety and a weak road hierarchy. However, Kuala Lumpur does enjoy a high level of road capacity per capita, perhaps the best indicator of road quality used here. Such inconsistencies in the relationship between modal and road variety likely reflect, as much as anything, problems with the road hierarchy indicator itself.

Overall, Medan appears to have the most diverse makeup of transportation modes among the cities studied. With a rich mix of buses, minibuses, opelets, bemos, and

Figure 2. Changes in Mode Type Diversity of Six Southeast Asian Cities

Figure 3. Changes in Diversity of Mode Capacities for Six Southeast Asian Cities

motorized (sidecart) becaks, it scored much higher than any other city both with respect to mode types and mode capacities. At the opposite end of the spectrum is Singapore and Kuala Lumpur, both of which, because of heavy government regulations, offer the traveling public limited mass transit choices.

Because data for multiple time points were available, it was possible to plot changes in various indicators over time for six of the cities. Plots on changes in mode type diversity and mode capacity diversity were most revealing and are shown in Figures 2 and 3 respectively. Figure 2 indicates that over the years, the types of modes have diversified in four of the six cities. The greatest diversification occurred in Surabaya, Manila, and Singapore. The introduction of microbus and mikrolet services in Surabaya as replacements for pedicabs (becaks) accounts for Surabaya's gains. Manila's increased diversity is most reflected by the shift in passenger vehicles from jeepneys to private automobiles while Singapore's gains can be attributed to the rapid growth in bus transit, in particular double-decker vehicles. By comparison, both Jakarta and Bandung have witnessed modal consolidation over time as a consequence of increased government bans and restrictions. In particular, Jakartans have seen the wholesale elimination of opelets, mebeas, mobets, minicars, helicaks, and super helicaks over the past decade.

Figure 3 charts changes in mode diversity (i.e., adjusting for the average seating capacity of each mode). In general, the same patterns hold. Accounting for the wide ranges of seating capacity — from two person motorcycles, to 5 person private cars, to 16 person jeepneys, to 24 person minibuses, and to 50 passenger stage buses—gives Manila the greatest modal variety.

5.3 Test of Hypotheses

Again, the overarching hypothesis of this research is that the mix of urban transportation modes in Southeast Asian cities is a market response to the inadequacies of existing road facilities. In general, the greatest mix of paratransit types and capacities can be expected where road capacity is limited (with respect to population) and there is a poorly developed road hierarchy. For the specific measures developed to test this hypothesis, the direction of causation can be stated. Table 4 summarizes the expected signs of correlations between the two measures of modal diversity and the three measures of road quality. In general, they should be negatively associated — where road capacity and hierarchy is deficient, the types and capacities of modes can be expected to be more varied as a compensating factor. The exception is with respect to the "road capacity variety index". With a good road hierarchy, there should be little variation in the capacity of different classes of roads once the number of lanes (or, as in this case, ordinal weight) is accounted for. Thus, a low road capacity index (indicating capacity balance) should be associated with low mode diversity indexes (meaning less dependency on modes of varying seating capacities). Conversely, a high road capacity index (indicating imbalance) should be offset by high mode diversity indices. Thus, the expected association between these measures is positive.

It should be noted that the causality postulated between these factors is temporal. That is, modal characteristics are viewed as responses to road supply characteristics. Thus, in a statistical sense, the various road indicators are explanatory variables and

Table 4.
Expected Signs of Correlations between Modal Diversity and Road Quality Indicators

Road Indexes	Mode Indexes	
	Mode Type Diversity	Mode Capacity Diversity
Road Kilometers per 100,000 Population	-	-
Road Hierarchy Index	-	-
Road Capacity Variety Index	+	+

Table 5.
Correlations between Modal Diversity and Road Quality Indicators for Eight Southeast Asian Cities¹

Road Indexes	Mode Indexes	
	Mode Type Diversity	Mode Capacity Diversity
Road Kilometers per 100,000 Population	-0.52	-0.48
Road Hierarchy Index	-0.28*	-0.36*
Road Capacity Variety Index	+0.18	+0.40

Notes:

¹ Correlations measured as Pearson product-moment correlations. Because of multiple time points, most correlations are based on 16 observations (N=16).

* Computations based on statistics from Table 3 for each city for the latest year only. Thus, for these computations, the number of observations was 8 (N=8).

represent antecedent events whereas the modal indicators are dependent variables and represent consequent events (Asher, 1982).

Table 5 presents the Pearson product-moment correlations derived for the pooled data across the eight cities. The signs of the correlations match *a priori* expectations and the associations are moderately strong.¹ Specifically, among the cities studied:

- * modes tend to be more diverse, both in types and seating capacities, when and where there are relatively small amounts of road capacity per capita. Thus, they appear to compensate for low capacities; additionally,
- * modes tend to diversify where there is a lack of variation in types of road (suggesting a lack of hierarchy); and, lastly,
- * modes tend to diversify when and where the aggregate vehicular capacities of classes of roads are quite different, a sign that the road network is not hierarchically well developed.

Overall, the hypotheses tested in this research are empirically borne out. Southeast Asia's paratransit sector, unhampered by strict entry and service regulations, appears to have evolved so as to compensate for inadequate road capacity and weak network hierarchy. Apparently, the urban transport market has responded to the inadequacies of the physical road plant. Accordingly, great care should be exercised in regulating paratransit modes. If done too quickly or without sound economic reason, the results could be counterproductive.

6. Conclusion

The paratransit sector has historically been the backbone of the transportation systems of Southeast Asian cities. Over the years, it has shown to be remarkably innovative in providing highly demand-responsive services. Most modes have carved out unique and distinct market niches — pedicabs and three-wheelers link narrow residential alleys to mainline bus routes. Microbuses provide access to nearby markets, and minibuses and medium-sized fleets connect cross-town neighborhoods and major urban centers. Paratransit has relieved governments from subsidizing public transit and making costly infrastructure investments. Driven by the profit motive, owners and operators of three-wheel scooters, microbuses, and jeepneys have carved out unique market niches, responding to travel demands when no one else would. In terms of seating capacities, operating speeds, and geographic coverage, Southeast Asia's paratransit sector appears to have adapted

¹ For four of the six correlations, 16 pooled cross-sectional longitudinal data were used. For the remaining two correlations — between the mode diversity indicators and the road hierarchy index — only eight data points were used. This is because road hierarchy tended to vary considerably across cities but relatively little over time within cities. This reflects the fact that once a road system is in place, it is fairly long lasting. Road additions occur gradually, at least compared to modal additions which appear to be growing exponentially in many instances. Thus, including longitudinal data in the measurement of road hierarchy would have yielded a small level of variation and, thus, insignificant correlations. Comparing patterns simply across the eight cities, however, captured much stronger cross-sectional variation. For this purpose, data were used for each of the eight cities for the latest year only.

well to available roadway infrastructure. Modally, it has compensated for road capacity and network deficiencies by providing the combination of seating capacities and speeds that ensure efficient levels of passenger throughput. Based on this research, paratransit appears to be a modal adaptation to the present-day inadequacies of roadway systems.

To the extent that road facilities begin to improve in step with increased private automobile ownership, these findings likewise suggest that paratransit's role should likely diminish over time. However, any retrenchment in paratransit services should be guided by market conditions, not by heavy-handed or unprincipled government regulations. That is, as traffic flows improve and more travelers opt for private modes of transport, the paratransit market itself can be expected to respond in the form of operators cutting back on routes and consolidating services. Overall, government's regulatory role should be limited to ensuring that vehicles and their drivers meet safety, licensing, and indemnity standards. Market entry and exit, paratransit service levels, and fares should be largely left to competitive market forces.

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Table A1. Mode Diversity and Road Deficiency Indices for Bandung, Indonesia

BANDUNG							
Mode	Vehicle Capacity*	Bandung (1972)		Bandung (1980)		Bandung (1987)	
		No.	Total Capacity	No.	Total Capacity	No.	Total Capacity
Passenger Car & Jeeps	5	25,600	128,000	65,080	325,400	83,757	418,785
Taxi	4	10	40	210	840	341	1,364
Motorcycle	2	115,400	230,800	154,992	309,984	218,185	436,370
Buses (conventional)	50	614	30,700	2,112	105,600	2,491	124,550
Mini bus	24	64	1,536	968	23,232	2,679	64,296
Oplet, Sudako, Kolt	14	1,610	22,540	1,105	15,470	3,277	45,878
Bemo, Mini Car, Kijang	7	380	2,660	771	5,397	3,988	27,916
Average		20,525	59,468	32,177	112,275	44,960	159,880
Standard Deviation		39,689	81,379	54,795	134,002	76,074	172,958
Coef. of Variation		1.93	1.37	1.70	1.19	1.69	1.08

* Exclusive of driver for public transport modes

Road Category	Ordinal Rating	Bandung (1972)		Bandung (1980)		Bandung (1987)	
		Kms	Variety Index	Kms	Variety Index	Kms.	Variety Index
Arterial (> 10m wide)	5	28	140	35	175	38	190
Collector (8-10m)	3	103	309	130	390	160	480
Local (< 8m)	1	310	310	351	351	364	364
Average		147	253	172	305	187	345
Standard Deviation		119	80	132	94	134	119
Coef. of Variation		0.81	0.32	0.77	0.31	0.72	0.35

Sources:

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Table A2. Mode Diversity and Road Deficiency Indices for Bangkok, Thailand**BANGKOK**

Mode	Vehicle Capacity*	Bangkok (1983)		Bangkok (1988)	
		No.	Total Capacity	No.	Total Capacity
Passenger Car & Jeep	5	378,430	1,892,150	523,599	2,617,995
Taxi	4	13,500	54,000	17,691	70,764
Motorcycle	2	390,722	781,444	527,794	1,055,588
Buses	34	7,400	251,600	8,749	297,466
Minibus, silor	18	7,500	135,000	7,300	131,400
Tuk Tuk & Samlors	3	7,700	23,100	12,200	36,600
Average		134,209	522,882	182,889	701,636
Standard Deviation		177,085	662,750	242,427	924,347
Coef. of Variation		1.32	1.27	1.33	1.32

* Exclusive of driver for public transport modes

Road Category	Ordinal Rating	Bangkok (1983)		Bangkok (1988)	
		Kms	Variety Index	Kms	Variety Index
Expressway	7	27.1	190	27.1	190
Arterial	5	375.0	1,875	390.1	1,951
Collector/Distributor	3	510.5	1,532	524.7	1,574
Local	1	1,746.5	1,747	1,870.2	1,870
Average		665	1,336	703	1,396
Standard Deviation		649	673	698	710
Coef. of Variation		0.98	0.50	0.99	0.51

Sources:

- Phiu-Nual, K. Review of Problems and Transportation Management Projects in Bangkok, Civil Engineering Department, Chulalongkorn University, 1987.
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- Kedkovid, S., et al., Public Transportation System in Bangkok, University of the Philippines Transport Training Center, 1989.

Table A3. Mode Diversity and Road Deficiency Indices for Jakarta, Indonesia

JAKARTA					
Mode	Vehicle Capacity*	Jakarta (1980)		Jakarta (1988)	
		No.	Total Capacity	No.	Total Capacity
Passenger Car & Jeeps	5	222,345	1,111,725	398,269	1,991,345
Taxi	4	6,165	24,660	9,785	39,140
Motorcycle	2	428,144	856,288	735,630	1,471,260
Buses (conventional)	55	3,267	179,685	4,762	261,910
Buses (double decker)	84	223	18,732	160	13,440
Minibus, Mikrolet	16	4,518	72,288	9,960	159,360
Bemo	7	1,085	7,595	1,096	7,672
Bajaj	2	10,956	21,912	14,612	29,224
Opelet	14	3,034	42,476	0	0
Mebea, Mobet	7	156	1,092	0	0
Mini car, Helicak	2	2,183	4,366	0	0
Average		62,007	212,802	146,784	496,669
Standard Deviation		131,652	370,732	256,865	729,147
Coef. of Variation		2.12	1.74	1.75	1.47

* Exclusive of driver for public transport modes

Road Category	Ordinal Rating	Jakarta (1980)		Jakarta (1988)	
		Kms	Variety Index	Kms	Variety Index
Arterial	5	868	4,340	1,084	5,420
Collector	3	1,232	3,696	1,709	5,127
Local (Kampung/Desa)	1	728	728	790	790
Average		943	2,921	1,194	3,779
Standard Deviation		212	1,573	383	2,117
Coef. of Variation		0.23	0.54	0.32	0.56

Sources:

Kantor Statistik Propinsi DKI Jakarta, Jakarta Dalam Angka, 1980-1987.

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Table A4. Mode Diversity and Road Deficiency Indices for Kuala Lumpur, Malaysia

KUALA LUMPUR (1985)

Mode	Vehicle Capacity*	No.	Total Capacity
Passenger Car & Jeeps	5	146,750	733,750
Taxi	4	5,928	23,712
Motorcycle	2	126,027	252,054
Buses	50	1,920	96,000
Minibus	24	490	11,760
Average		56,223	223,455
Standard Deviation		65,806	269,138
Coef. of Variation		1.17	1.20

* Exclusive of driver for public transport modes

Road Category	Ordinal Rating	Kms	Variety Index
Expressway	7	89.3	625
Primary Distributor	5	269.0	1,345
Secondary Distributor	3	203.1	609
Local	1	144.8	145
Average		177	681
Standard Deviation		67	429
Coef. of Variation		0.38	0.63

Sources:

- Kuala Lumpur Planning Department, The Kuala Lumpur Structure Plan, 1988.
 Wilbur Smith and Associates, Urban Transport Policy and Planning Study for Metropolitan Kuala Lumpur, 1974.
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 Japan International Cooperation Agency, Klang Valley Transportation Study, 1986.
 Road Transport Department, Motor Vehicles Registered by Type of Vehicle, 1980-86.

Table A5. Mode Diversity and Road Deficiency Indices for Manila, Philippines**MANILA**

Mode	Vehicle Capacity*	Manila (1982)		Manila (1988)	
		No.	Total Capacity	No.	Total Capacity
Passenger Car & Jeep	5	265,022	1,325,110	430,425	2,152,125
Taxi	4	10,125	40,500	12,100	48,400
Motorcycle	2	38,609	77,218	43,688	87,376
Buses	50	3,591	179,550	4,060	203,000
Minibus	24	1,500	36,000	822	19,728
Jeepney	16	37,000	592,000	30,788	492,608
Average		59,308	375,063	86,981	500,540
Standard Deviation		93,193	466,098	154,322	755,275
Coef. of Variation		1.57	1.24	1.77	1.51

* Exclusive of driver for public transport modes

Road Category	Ordinal Rating	Manila (1982)		Manila (1988)	
		Kms	Variety Index	Kms	Variety Index
Primary	5	800.2	4,001	858.6	4,293
Secondary	3	880.7	2,642	945.0	2,835
Local	1	1,057.1	1,057	1,134.2	1,134
Average		913	2,567	979	2,754
Standard Deviation		107	1,203	115	1,291
Coef. of Variation		0.12	0.47	0.12	0.47

Sources:

- Ministry of Transportation and Communication, Metro Manila Urban Transportation Strategy Planning Project, Australian Development Assistance Bureau, 1984.
- Japan International Cooperation Agency, The Metro Manila Transportation Planning Study, 1985.
- Rimmer, P. Rickshaw to Rapid Transit: Urban Public Transport Systems and Policy in South-east Asia, Sydney: Pergamon Press, 1986.
- Galvante, E. et al., Urban Transport Problems in the Philippines, Prospect for Solution, Transport Training Center, University of the Philippines, 1988.

Table A6. Mode Diversity and Road Deficiency Indices for Medan, Indonesia

MEDAN (1988)

Mode	Vehicle Capacity*	No.	Total Capacity
Passenger Car & Jeeps	5	44,147	220,735
Taxi	4	5,928	23,712
Motorcycle	2	163,183	326,366
Buses**	50	2,200	110,000
Microbus/Opelet**	12	6,000	72,000
Bemo**	7	4,000	28,000
Motor Becak**	3	4,000	12,000
Average		16,788	50,253
Standard Deviation		54,986	109,688
Coef. of Variation		3.28	2.18

* Exclusive of driver for public transport modes

** Estimates presented

Road Category	Ordinal Rating	Kms	Variety Index
Arterial	5	63.4	317
Collector	3	252.0	756
Local	1	315.0	315
Average		210	463
Standard Deviation		107	207
Coef. of Variation		0.51	0.45

*** Kilometers of roads for Kotamadya Medan estimated from downtown area

Sources:

Renee-Park, GmbH. Central Area Action Plan, Kotamadya Meda, IBRD Medan Urban Transport Project, 1989.

Soegijoko, B.. Public Transportation in Some Indonesian Cities, ITB, 1980.

Table A7. Mode Diversity and Road Deficiency Indices for Singapore

SINGAPORE							
Mode	Vehicle Capacity*	Singapore (1972)		Singapore (1982)		Singapore (1987)	
		No.	Total Capacity	No.	Total Capacity	No.	Total Capacity
Passenger Car & Jeeps	5	122,671	613,355	179,670	898,350	223,456	1,117,280
Taxi	4	4,930	19,720	10,283	41,132	10,552	42,208
Motorcycle	2	76,574	153,148	136,899	273,798	115,476	230,952
Buses (conventional)	56	3,724	208,544	6,808	381,248	8,133	455,448
Buses (Double Decker)	88	0	0	390	34,320	450	39,600
Average		51,975	248,692	66,810	325,770	71,613	377,098
Standard Deviation		50,360	221,443	75,970	316,098	86,951	400,356
Coef. of Variation		0.97	0.89	1.14	0.97	1.21	1.06

* Exclusive of driver for public transport modes

Road Category	Ordinal Rating	Singapore (1972)		Singapore (1982)		Singapore (1987)	
		Kms	Variety Index	Kms	Variety Index	Kms.	Variety Index
Expressway	7	60	420	85	595	100	700
Arterial	5	250	1,250	427	2,135	507	2,535
Collector	3	117	351	199	597	236	708
Local	1	1,048	1,048	1,678	1,678	2,001	2,001
Average		369	823	597	1,356	711	1,621
Standard Deviation		375	340	593	574	703	678
Coef. of Variation		1.02	0.41	0.99	0.42	0.99	0.42

Sources:

- Spencer, A. and Chia, L., *National Policy Towards Cars: Singapore*, Transport Reviews, Vol. 5, No.4, 1984, pp. 301-323.
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- Leng, Y. and Leng, W., *Urban Transportation Problems in Singapore: Prospects for Solution*, Transport Training Center, University of the Philippines, 1988.
- Been, C. and Chin, Y., *Public Transportation Systems in Singapore*, University of the Philippines Transport Training Center, 1989.

Table A8. Mode Diversity and Road Deficiency Indices for Surabaya, Indonesia

SURABAYA

Mode	Vehicle Capacity*	Surabaya (1976)		Surabaya (1988)	
		No.	Total Capacity	No.	Total Capacity
Passenger Car & Jeep	5	25,000	125,000	54,006	270,030
Taxi, Opelet	4	2,100	8,400	1,773	7,092
Motorcycle	2	115,400	230,800	324,833	649,666
Buses	56	70	3,920	2,703	151,368
Bemo	7	2,000	14,000	662	4,634
Minibus, Mikrolet	12	0	0	820	9,840
Average		28,914	76,424	64,133	182,105
Standard Deviation		44,205	89,412	118,157	230,611
Coef. of Variation		1.53	1.17	1.84	1.27

* Exclusive of driver for public transport modes

Road Category	Ordinal Rating	Surabaya (1976)		Surabaya (1988)	
		Kms	Variety Index	Kms	Variety Index
Primary Arterial	7	110	770	112	784
Secondary Arterial	5	127	635	132	660
Secondary Collector	3	174	522	286	858
Secondary Local	1	187	187	128	128
Average		150	529	165	608
Standard Deviation		32	216	71	286
Coef. of Variation		0.21	0.41	0.43	0.47

Sources:

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