Mobility Issues in the Developing World

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Fall 1997

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In the large cities of the developing world, travel times are generally high and increasing, destinations accessible within limited time are decreasing. The average one-way commute in Rio de Janeiro is 90 minutes. In Bogota it is 60 minutes. The average vehicle speed in Manila is 7 miles per hour. The average car in Bangkok is stationary in traffic for the equivalent of 44 days a year.

This is happening because vehicle registrations are growing fast on the basis of increased populations, increased wealth, increased commercial penetration, and probably an increasingly persuasive picture in the developing world of international lifestyle in which a car is an essential element. Accordingly, in much of the developing world the number of motor vehicles is increasing at more than 10 percent a year--the number of vehicles doubling in 7 years. The countries include China (15 percent), Chile, Mexico, Korea, Thailand, Costa Rica, Syria, Taiwan, and many more.

What is the shape of increasing congestion and declining mobility? There are no widespread measures available for comparative purposes because decline in mobility is complicated. Congestion is always localized in time and space. A few things are nonetheless evident.

1. Congestion is reducing the mobility of auto users. It is clear by measures of traffic delay available an even by impressionistic evidence that in virtually all large cities of the developing (and developed) world congestion increasingly impedes mobility for auto users. The only exceptions are very poor metropolitan areas, some cities in the initial stages of relief from planned economy (e.g. Tashkent), and a very few with successful traffic management (of which the flagship example is Singapore).

2. Mobility is declining even more for public transport users. This is largely because transit routes characteristically follow the highest volume arteries, those most afflicted with congestion. Further, transit networks are usually dominantly radial, not permitting cross-town avoidance of congestion. Finally, transit users are not able to follow trip destinations that are displaced into the higher accessibility locations at the periphery because the transit network does not serve them.

3. For the numerous individuals newly acquiring cars in the developing world, however, mobility is rising. This is simply because they are removing themselves from plight 2 above to plight 1, which is less severe.

The conflicting interest between group 3 above and the first two is, of course, one way to define the mobility problem.

THE DEVELOPING CITY AS A PLATFORM FOR MOBILITY

The cities of the developing world are growing fast. In 1950 less than 30 percent of the world's population were urban dwellers. By 2005 it will be half. Since 1950 the number of urban dwellers has more than tripled. This growth has recently surfaced interest in "megacities" (more than 8 million people). They are primarily a feature of the developing world. In 1994 sixteen of the

twenty-two megacities were in developing countries. By 2015 twenty-seven of the thirty three megacities will be in developing countries.

The Megacities

Megacities, in addition to becoming more numerous, are becoming much larger. In 1950 the smallest of the top 15 cities in the world was 3.3 million population. in 1994 the smallest of the top 15 was 9.8 million. Growth is rapid. During the period 1970 to 1990 the population of Dhaka increased by an average of 6.7 percent/year. Lagos grew by 6.7 percent/year (United Nations 1995).

Megacities are very different from one another, but many of them share certain similarities in general conditions, in their relationships to their respective countries, and in their mobility problems and opportunities. The demands imposed by rapid growth are daunting, resulting in lagging public services--especially water and sewerage-- in many megacities. These cities also attract marginal populations whose needs are not met in several respects, including mobility. There is, however, a positive side. Compared at least with secondary cities of their own countries, megacities usually have better public facilities. They typically get the lion's share of public investment and policy attention because they house a more affluent population with higher expectations. They are also more familiar to influential decision makes and are a source of national pride. As a result, the worst general service problems are in Santos not Sao Paulo, Surabaya not Jakarta, and Damanhur not Cairo. In particular, the transportation facilities of the megacities are often considerably better, both highway and public transport.

In any case, seen exclusively from the perspective of mobility, rapid urban growth can be a distinct advantage. The big problem with the developing city is that it is a premotorized city with densities that may rise to as much as 4 to 5 times the level of a Western European city with no prospects of making room for cars at any significant level of use. Yet the attractions of motorization increase the number even when vehicle use faces severe practical limitations.

There are grounds for saying that the severity of the mobility problem under pressures of motorization is measured by the speed of motorization compared with the speed with which the city can adjust to deal with the new structure of mobility demand. This is obviously easier for a city that is growing fast. In today's large city it is not unusual for the outer periphery to be expanding at some 10 to 20 percent a year. This growth makes rapid adjustment possible.

The first obligation of mobility in the developing city is to enhance the unique, essential functions of the large city. They are of special importance to a country whose central concern is economic development. Bangkok includes only 10 percent of the population of Thailand, but accounts for 86 percent of the country's GNP in banking, insurance and real estate, and 74 percent of it's GNP in manufacturing (Kasarda and Parnell, 1993). More broadly, large cities are sure to be centers of education, research, innovation of all sorts and the various aspects of globalization that are bringing the developing countries into the world-wide production system. The decline of

mobility is damaging these roles significantly. Bangkok loses 35 percent of its GCP in congestion.

Recently Remy Prud'homme has been arguing that industry benefits from access to labor force, so the larger the city the better (Prud'homme, 1994). But he points out that it depends, of course, on adequate accessibility. Further, large cities have higher wage rates and therefore higher costs per hour for time lost in congestion. They also have higher construction costs for transportation facilities. As a result, loss of mobility though congestion is more expensive to the national economy in large cities.

Another problem of the developing megacity is that the split of spatial domain between the motorized population and the non-motorized population is great. In cities ranging up to 250 persons per hectare (as in China) auto ownership and use are heavily constrained. As a result decentralization with motorization is explosive. Valued activities in the hands of the motorizing part of the population evacuate to the suburbs, leaving the city for only low income activities. Employment, increasingly in decentralized settlements is not accessible to non-motorized, lower income workers.

Under these circumstances the viability of public transport is particularly important. But public transport in every city is dominated by buses and they, as mentioned above, are generally more susceptible to increasing congestion than cars. There are possibilities of escaping this problem by assertive management of transit right of way through such means as independent lanes or signalization that favors transit vehicles. The prospects for the improvement of mobility by this means are important, but few cities have been successful because under circumstances of increasing congestion the pressure to favor general use of the streets is high--automobile owners are a powerful lobby in most of the developing world.

The prospect of increasing mobility through transit on independent rights of way remains an ambition of the transportation community. The stakes are high because of the importance of mobility to retaining the economic viability of the city as well as for the other reasons discussed here, but the costs of providing these facilities are high.

One of the fundamentals of the large developing city as a platform for motorization is that capital is scarce and operating subsidies difficult to sustain. Cointreau-Levine points out that solid waste management consumes 20 to 50 percent of local expenditures in megacities (Cointreau-Levine, 1994). Some of those cities are virtually unsewered (e.g. Bangkok, Riyadh), and most of them have severe deficits of sewerage. These are circumstances that leave high net expenditures for public transport in discouraging prospect.

Controlling City Size

Should governments make efforts to control city size? There were strong efforts during a number of years to control the size of large cities and determine possible levels of optimality of city size. Planners based this on a belief that large cities were socially dysfunctional, disproportionally resource consuming, and that they induced unhealthy crowding especially because of the accumulation of populations attracted by economic opportunity but unable

to benefit by it. In recent years these concerns have been largely dropped. In the first place, the essential role of cities in economic development has attracted attention–the large city role in globalism, labor productivity, education, innovation, and so forth. It is not clear that greater city size enhances all these functions, but it surely does enhance some of them (such as labor productivity). Large cities are also likely to be more ecologically sustainable because they are likely to employ more advanced industrial technologies and to have administrations with more environmental foresight. They may also consume less of their nations' valuable land than smaller scale urbanization because their densities are higher. It is not clear that large cities consume resources disproportionally unless it is a result of their higher standard of living, a problematic basis for constraining their resource consumption. Nor it is clear that they suffer increased social dysfunctionality. In sum, much of the critique of the megacity has been based on an anti-urban tradition that has run its course.

Secondly, the effort to limit city growth has been notably unsuccessful, even in the most authoritarian regimes. China had a requirement for many years that families could not change their locality of residence without permission from administrations both at the origin and destination. This policy has not kept a large "floating population" from accumulating at Beijing. Efforts to close migration to Jakarta in the 1970s and to Manila in the 1960s met with failure. A few cities have used strong land development control techniques to confine the expansion of urban areas. Their principal effect has been to shift population outwards within the metropolitan area. This has dramatically been the case in Seoul as a result of its firmly defended green ring.

The large city may suffer proportionally more from congestion. It is sure to be the case that no city in Colombia but Bogota has a commute time of one hour, and the secondary cities of Egypt and Thailand do not suffer nearly the congestion of their capitals. This is partly because trip length tends to increase with city size and because the increased number of vehicles tend to congregate in disproportionally limited parts of the city, especially its center. At the same time, the largest cities are likely to be the most able to support rail rapid transit subsidies in exchange for their benefits in high volume throughput.

The summary is that there are good reasons to consider the megacity an opportunity for mobility enhancement, rather than a frustration. It is bound to be the testing ground for promising new technology, the place where budgets are most prepared to cope with the cost, the locus where mobility is the most valued, and where it will get the most public support.

BASIC MOBILITY ISSUES

The basic characteristics that differentiate the developing city in regard to transportation are:

1. Rapid pace of motorization. There is a significant portion of these cities where motorization is increasing at more than 10 percent a year. In China vehicles are increasing at 15 percent a year, automobiles at 25 percent a year. in Korea there was an annual increase averaging 23.7 percent for some

7 years following 1985. Pace of motorization is important because related systems, such as facility construction and land use densities cannot keep up, resulting in enormous congestion. How else could Bangkok be more congested on a national average of 54 vehicles per 1000 population than American cities on national average 750 vehicles per 1000.

2. Travel demand far exceeding the supply of facilities. High levels of congestion and high latent demand for travel is the result of motorization outstripping any possible expansion of highways. This condition exists in nearly all developing countries, except for a few very wealthy ones (c.f. the Gulf States) and some with such low initial motorization rates that the increase has not yet caught up with capacity. In some cases the prospects for privatization are sufficiently good and right-of-way acquisition obstacles so benign that the question of "how many highways to build?" is topical (viz. China). But there are not many countries in this situation.

3. High share of trips by public transit. Across much of the developing world urban vehicular trips are around 75 percent by transit. Exceptions include China, where a significant percentage are bicycle trips. this means that making public transport work has high priority and swamping buses in auto congestion is a difficult problem.

4. Intense desire for auto ownership and use. According to government surveys, Chinese families are likely to be prepared to spend 2 years' income for a car that is expected to last for 10 years. (Americans spend about 27 weeks' salary.) Auto shows are thronged. Teenagers hang posters of cars in their rooms. Auto owners convert to public transport only with the greatest reluctance; in fact, to a first approximation they simply don't.

5. Urban structure incompatible with motorization. Residential densities in China are as high as 200 to 250 persons per hectare. (The Western European city is about 50 persons/hectare.) Street space is around 10 percent of the city surface (rather than 25 percent in the western city). Land use is likely to be more mixed than in the western city and the average urban trip length much shorter (The average bike trip in Shanghai is 3.5 to 5 km. in a city of 20m people.) The lack of street space and parking results in forceful decentralization of land use.

6. Stronger land use/transportation relationship. Changes in the access system, such as through the construction of a new urban highway, has much more impact on urban development in a developing city simply because there are fewer high speed roads. The new one therefore provides more comparatively attractive access than in the developed city, where peripheral access is high in every direction. Also, more rapid urban growth (likely to be in the range of 5 percent per year) results in more rapid change and therefor more change responsive to recently built facilities.

Further, in some parts of the developing world where motorization is rapid, governments have considerable influence, current or potential, to guide land use into mobility-friendly forms. This is partly because local government, as in China and Korea, is less divided within metropolitan areas. Unified metropolitan administration is important because small sub-metropolitan jurisdictions seldom take great interest in access. At the same time they are more authoritarian. It should also be important that the rapidly

motorizing countries, on account of great congestion and rapid decentralization, have much more at stake in guiding land development than the western countries ever had. The problems resulting from inattention to this matter are much more severe.

7. Greater differences in vehicle performance. The wide variety of vehicle types on the streets presents difficult problems of efficiency and safety. Many cities have passenger vehicles ranging from human traction to high-speed sports cars, and every scale of freight vehicle. According to Darbera and Nicot (1984) there are 16 modes of public transport on the streets of the cities of India. In China, while it is surely essential to assure the survival of adequate ways for bicycles, it is unquestionably inefficient for the street lanes to be divided into motor and non-motor lanes, especially because of difficulties of movements at intersections.

8. Inadequate street and highway maintenance. Highways and arterials are built by national agencies and maintained by local governments. No funding provisions are made for the maintenance, however, and the local government often has scarcely the funding to collect the trash. As a result, transport ways are often in very bad condition. Indeed, sometimes they are intentionally left that way because the local administration hopes the national agency will step in again when the deteriorated condition of the road is so bad that repair is in effect full reconstruction.

9. Irregular response to impacts of new construction. In some countries new urban facilities are very difficult to build. Projects encounter strong movements of resistance from impacted institutions and communities (especially in Latin America). In others, there is very little resistance (e.g. China). Air pollution is a matter of intense concern in certain cities (e.g. Bangkok) and very little in others (e.g. Cairo). There are indications that air quality is increasing as a concern in areas where it was not previously a major preoccupation. For example, a recent issue of India Today (December 15, 1996) bears a cover headline "Choking to Death: Polluted Cities," and a cover story titled "Gasping for Life."

10. Fewer legal constraints on the use of new technologies. One of the strongest constraints on the introduction of new technologies, for example, for driver advisory functions, in the West is fear of legal suite. This concern is less problematic in the case of the developing world, making innovation more feasible on this account.

11. Driver discipline weak in many countries. While driver discipline is equally strong or stronger in many East Asian countries than in the West, it is certainly weaker in most of the developing world. This is a problem for the implementation of many forms of traffic management. For example, transit only lanes have been attempted in several cities where it was found that drivers would simply not respect them.

12. Very limited agreement on planning approaches. Whereas the Western countries have cadres of engineers and planners with reasonably consistent perspectives on dealing with urban transportation problems (however much they may disagree on the details), the developing countries characteristically do not. They tend to borrow method and professional perspective from elsewhere and to have professional communities that are at

crossroads of ideas, without stable commitments. This results in turbulence in the course of transportation problem solving, stalemates when trying to marshal strength to a particular solution and rapid change of strategies over time that keeps any strategy from having sound effect. This is a serious problem in transportation because there are so many alternative views. It presents an important need for professional education and leadership as a foundation for meaningful problem solving.

CONGESTION AND MOTORIZATION IN THE DEVELOPING WORLD

There are no satisfying widely used measures that document the decline of mobility and serve to project it. To even casual observation, however, it is clear that congestion is increasing in most major cities. In the cities of China, India and Indonesia, rush hour speeds got slower through the 1980s, reaching speeds of less than 10 kilometers an hour in major cities of those countries. In central Bangkok traffic speeds declined by 2 percent per year in the second half of the 1980s, and the average car is estimated to spend fully 44 days per year stationary in congestion. (World Bank, 1994, p. 16). These figures are believable, not only through intuitive observations, but because it is an expected consequence of rapid motorization. Even in Los Angeles, California, where growth is slow in comparison, it would take 851 lane-kilometers (of freeway and arterial street) to maintain current levels of mobility, 201 lane-kilometers in Cleveland. (Schrank et al., 1994, p. xv)

Congestion has been estimated for the US through hours of traffic delay. The Texas Transportation Institute has developed a Roadway Congestion Index in which the independent variables are freeway vehicle-kilometers traveled/freeway lane-kilometers and arterial kilometers traveled/arterial-kilometers. This index has increased for cities across the US by roughly 20 percent during the period 1982-1991 (with a good deal of variation among cities.) TTI also estimated that during 1984 to 1991, for 50 large US cities total daily vehicle hours of delay increased by 21 percent. For a number of individual US cities it increased 30 to 50 percent. (Schrank et al., 1994, p. 31). (Note this is not per vehicle. It includes increases in number of vehicles and vehicle miles traveled.) These levels of increase under the circumstances of modest increase in motorization and urban population growth in US cities suggest the future consequences in the developing world because of much larger increases in both, and in many cases already more congested roads.

A somewhat similar measure has been attempted for the developing world for the UN Population Fund by the Institut d'Etudis Metropolitans de Barcelona (UNPF, 1988), but the effort is still in a primitive stage. There is no historical sequence of estimates and the survey appears to have included all roads (in part because freeways and arterials are hard to isolate in many developing cities). The measure uses vehicle registrations rather than vehicle kilometers traveled. Unsurprisingly, the ratio of vehicles/kilometer of road is much higher for the developed cities. This tends to confirm the facts that (1) congestion is a condition localized to main ways that cannot be averaged over a whole network and (2) that the developing, pre-motorized city has local problems of adaptation to motor vehicles. We need further data to accumulate for developing cities.

Table 1: Motorization in Low Income Cities, 1985

Cities	Cars/ 1000
Shenyang	2.72
Lima	3.89
Beijing (M)	5.92
Abidjan	8.7
Shanghai	9.02
Guayaquil	11.82
Wuhan	19.45
Delhi	22.78
Karachi	38.83
Jakarta	41.11
Guangzhou	41.92
Ankara	44.22
Baghdad	46.48
Bangkok	59.38
Calcutta	72.5
Algiers	80.92
Brasilia	103.56
Belo Horizonte	128.03
Mexico City	155.35
Budapest	187.61
Warsaw	192.54
Curitiba	226.35
Sao Paulo	228.29

Table 2: Motorization in High Income Cities, 1985

Cities	Cars/ 1000
Brisbane	551.49
Vienna	331.98
Lyon	419.11
Marseille	380.95
Bonn	403.13
Cologne	338.67
Frankfurt	437.49
Munich	419.78
Hongkong	28.83
Rome	484.7
Kobe	155.13
Kyoto	186.74
Osaka	139.11
Sapparo	251.82
Tokyo	167.25
Amsterdam	306.58
Rotterdam	297.36
Seoul	30.77
Singapore	90.7
Barcelona	344.77
Madrid	317.37
Birmingham	257.8
Glasgow	156
Dallas	622.92
Denver	656.14
Milwaukee	445.79
New York	224.57

Table 3: City Population, Income, and Journey to Work Travel Time, Selected Cities, 1990

Country	City	City Population	Cars 1000 Pop. (country)	City Median Income	Journey to Work (Minutes)
Tanzania	Dal es Salaam	1,556,290	1.9	763	50
Malawi	Lilongwe	378,867	2.0	692	60
Bangladesh	Dhaka	5,225,000	0.4	1,352	45
Madagascar	Antananarivo	852,500	4.1	747	60
Nigeria	Ibadan	5,668,978	3.8	1,331	26
India	New Delhi	8,427,083	3.4	1,084	59
Kenya	Nairobi	1,413,300	5.5	1,500	24
China	Beijing	6,984,000	1.1	1,079	25
Pakistan	Karachi	8,160,000	6.4	1,622	NA
Ghana	Accra	1,387,873	5.5	1,241	35
Indonesia	Jakarta	8,222,515	7.2	1,975	40
Egypt	Cairo	6,068,695	19.8	1,345	40
Zimbabwe	Harare	1,474,500	30.2	2,538	56
Senegal	Dakar	1,630,000	8.6	2.714	35
Philippines	Manila	7,928,867	7.4	3,058	30
Cote d'Ivoire	Abidjan	1,934,398	12.9	3,418	38
Morocco	Rabat	1,050,700	26.7	4,158	25
Ecuador	Quito	5,345,900	15.4	2,843	56
Jordan	Amman	1,300,000	50.5	4,511	30
Colombia	Bogota	4,907,600	35.9	3,252	90
Thailand	Bangkok	6,019,055	21.4	4,132	91
Tunisia	Tunis	1,631,000	25.5	3,327	37
Jamaica	Kingston	587,798	28.3	3,696	60
Turkey	Istanbul	7,309,190	28.1	3,576	40
Poland	Warsaw	1,655,700	137.8	2,265	45
Chile	Santiago	4,767,638	53.9	3,433	51
Algeria	Algiers	1,826,617	29.0	7,335	30
Malaysia	Kuala Lumpur	1,232,900	103.3	6,539	34
Mexico	Monterrey	2,532,349	80.0	4,810	25
South Africa	Johannesburg	8,740,700	102.0	9,201	59
Venezuela	Caracas	3,775,897	80.2	5,123	39
Brazil	Rio de Janeiro	6,009,397	70.5	5,204	107
Hungary	Budapest	2,016,774	184.3	5,173	34
Czechoslovakia	Bratislava	441,000	207.0	3,677	40
South Korea	Seoul	10,618,500	32.1	19,400	37
Greece	Athena	3,075,000	172.9	14,229	40
Israel	Tel Aviv	1,318,000	174.5	16,680	32
Spain	Madrid	4,845,851	307.9	23,118	33
Singapore	Singapore	2,690,100	95.5	12,860	30
Hong Kong	Hong Kong	5,800,600	37.0	15,077	45
U.K.	London	6,760,000	363.5	18,764	30
Australia	Melbourne	3,035,758	435.6	26,080	25
Netherlands	Amsterdam	695,221	366.6	14,494	18
Austria	Vienna	1,503,194	387.9	22,537	25
France	Paris	10,650,600	417.3	32,319	40
Canada	Toronto	3,838,744	475.9	44,702	26
USA	Washington	3,923,574	574.3	49,667	29
Germany	Munich	1,277,576	485.3	35,764	25
Norway	Oslo	462,000	380.0	34,375	20
Sweden	Stockholm	647,314	420.7	41,000	33

Perhaps the most telling data on mobility problems in the developing city is in journey to work travel times. It has been noted that travel times are remarkably similar from city to city. This was noted by Zahavi in the 1970s and recently concluded by Kenworthy et al. (1997) from survey data. On a world wide basis (excluding developing countries) the figure is roughly 30 minutes for a wide variety of different cities. In the developing world, on the other hand, in a set of data provided by UNCHS (1992) there are several cities with average journeys to work (one way) around an hour for 1990. Those cities include Lilongwe (Malawi), Antananarivo (Madagascar), New Delhi, Harare, Quito, and Kingston in a list of 36. The top average work trip times were Rio de Janeiro at 107 minutes and Bogota at 90 minutes. Most megacities are for some reason missing from this list, but the cities with problematic commutes in general are not the larger ones. If we isolated special suburban populations with long trip times it is probable that the set would include numerous fast-growing mid-sized cities. For example, commuting trips of two hours occur from the suburbs of Kuala Lumpur--a metropolitan area of only 2 million (author's recent experience). Perhaps this is an indication that problems of urban mobility are not generic, but rather are special problems subject to correction.

PATHS OF MOTORIZATION

Growth in the number of motor vehicles is at the base of mobility, on the one hand as an indication of increased motor mobility of the population and on the other as a force toward increased congestion. Although its significance to each is difficult to resolve, it is the best recorded variable. The work toward understanding future trends in motorization has been surprisingly limited, but there have been some recent interesting proposals.

We have found that cars per 1000 population correlates very well with the annual income of the top 20 percent of population of the low income developing countries[1]. (See figure 1) Cars per 1000 also correlates well with percentage of the population in urban areas. To some extent, of course, percentage urban is a surrogate for income, since the vast majority of people in developing countries with incomes over the threshold of auto ownership live in cities (Gakenheimer and Steffes, 1995a).

Other economic indicators perform very poorly. We tried private consumption, industrial production (as a percent of GDP), openness of the economy (value of foreign trade/GDP), net current transfers (highlighting remittances from citizens overseas) and percentage of population in the labor force. None of these produced results of interest.

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[1] The low income developing countries are: Bangladesh, India, Pakistan, Ghana, Sri Lanka, Indonesia, Philippines, Ivory Coast, Guatemala, Morocco, Peru, and Colombia. (The lower middle income developing countries are Jamaica, Poland, Costa Rica, and Botswana. Upper middle are Malaysia, Venezuela and Brazil.)

Figure 1. Average Annual Income of Top 20% of Population vs. Motorization (Low Income Countries)

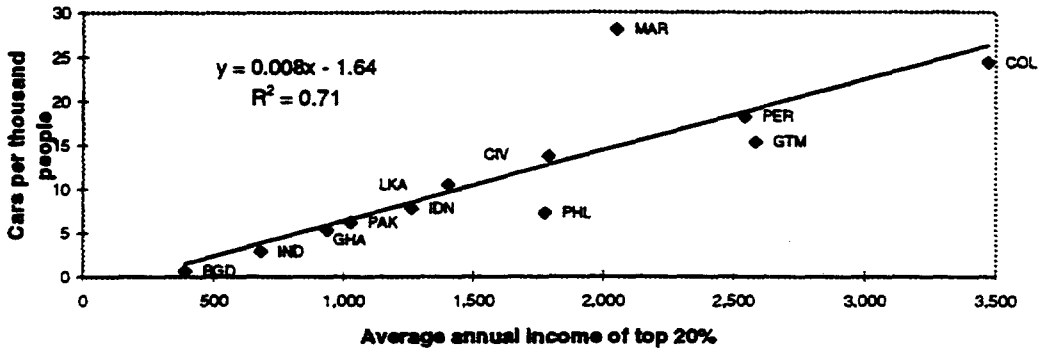
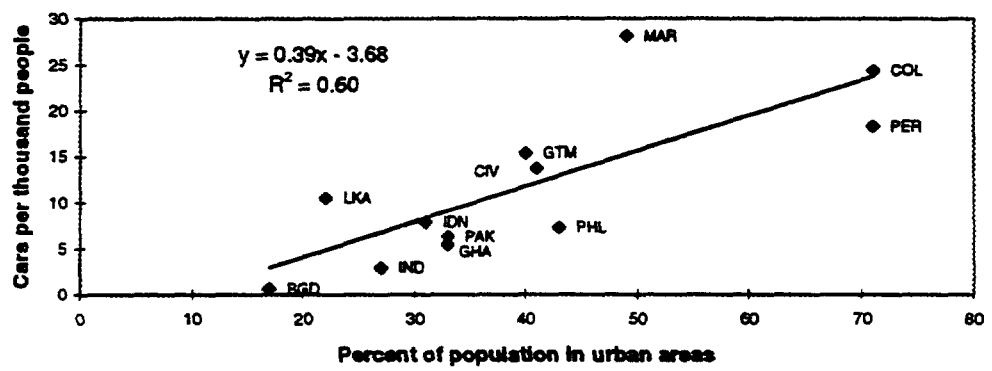


Figure 2. Percent of Population in Urban Areas Vs. Motorization (Low Income Countries)



Country	Abbreviation
Bangladesh	BGD
India	IND
Pakistan	PAK
Ghana	GHA
Sri Lanka	LKA
Indonesia	IDN
Philippines	PHL
Cote d'Ivoire	CIV
Guatemala	GTM
Morocco	MAR
Peru	PER
Colombia	COL

Several analyses have examined the income elasticities of motor vehicle ownership (based on GDP per capital), all yielding elasticities higher than one but with considerable variation (Stares and Liu, 1996, p. 47). Most recently Kain and Liu got 1.44 for all motor vehicles and 1.58 for passenger cars, using a 52 country sample. Interpretation presents problems when considering that the part of the populations in the developing countries with incomes over the car-owning threshold is a very small part of the total, and their income growth probably does not vary with the average, particularly in transitional economies. One might expect better relationship with commercial vehicles, but their elasticity for commercial vehicles in the Kain and Liu study was only 1.15. At worst, however, we can conclude that the elasticity is positive.

During the last 35 years most analysts have assumed that the variation conformed to a sigmoidal (logistic, "S" shaped) curve. This was established by J. C.. Tanner in the early 60s (Tanner, 1962) and further developed in a number of papers, especially from the United Kingdom. The sigmoidal curve was originally introduced for biological, and epidemiological phenomena. It later became used for analysis of the diffusion of technological innovation. It is an intuitively satisfying curve for a process that begins slowly, matures into break-neck growth and must slow down at some point. It has obvious special limitations, however, when applied to the developing countries where incomes are rising (or falling) and where motorization is far from reaching general saturation. In most of the developing world the decline toward the top of the "S" is not visible.

Some papers using the sigmoidal curve have interpreted the phenomenon as similar to technological innovation, where the process is one of increasing familiarity with the motor vehicle and adjustment of preferences to act on acquiring it (Jansson, 1989) Some have noted the need to shift the saturation rate upward repeatedly over time (Korver, 1993). Button et al. (1993) have proposed the use of a time variable to account for change in the relation between motorization and income. This may suggest the influence of increasing perception of a universal motorized life style, increasing market penetration of the industry, or similar effect. Mogridge (1989, p. 55) points out that "automobile ownership and new car registrations show one of the largest year-to-year fluctuations of any economic variable."

We may conclude that the sigmoidal curve surely has some interpretation that illuminates motorization, but that it does not usefully project any slow-down phase of motorization in most of the developing countries.

An entirely new interpretation has been introduced by Debu Talukdar (1997). He hypothesizes the relevance of the Kuznets curve. Originally introduced by economist Simon Kuznets to examine the relationship between economic development and income inequality, it has been used more recently to model the long term relationship between economic development and environment. It projects relationships in an inverse "U" form that rises, peaks and then falls. In the case of environment it suggests rising damage from development, followed by investor, citizen and policy reactions that reduce such impacts as development continues. Its relation to motorization might suggest a rise in motor vehicles followed by a per capita (not necessarily absolute) decrease based on response to congestion, loss of novelty, and adjustments of public policy.

Talukdar presents this curve as a quadratic equation and tests it against the sigmoidal curve and the log-linear form, using a sample of 49 countries with substantial historical depth, and including 29 developing counties. He finds that the Kuznets curve provides a better statistical description of the long term relationship between economic development and per capita motorization than either of the other two.

This research was recently completed as a thesis at MIT. The present data set indicates a peak in car ownership at the level of around $21,000 income. This does not mean that the developing countries need reach that level before experiencing some attenuation of motorization but it does suggest that significant influence of the concept in the developing world is in the distant future.

Another perspective on the future of motorized travel is offered by Andreas Schafer (Schafer, 1997). There has been a belief sustained by evidence over the last 35 years, initially by J. C.. Tanner and later Yakov Zahavi, that personal travel occupies a constant budget of cost and time on average. The cost amounts to some 10 percent of personal consumption expenditure. The time in travel is somewhat more than one hour per day. This means that as incomes rise and time availability remains constant, people will spend more on travel per unit time (presumably using faster modes). Schafer reasons that at very high incomes people will proportionally reduce street travel (though not necessarily motorization) in favor of faster modes.

Accordingly, modal adjustments may be in store. In 1990 about 50 percent of global travel (in passenger kilometers) was by car, 30 percent by bus, 10 percent by rail and 10 percent by air. (Almost 80 percent of global bus traffic occurred in the developing world.) Schafer estimates by the year 2020 a rise in air traffic at about double the 1990 figure, to 20 percent, and a consequent only gradual decrease in the share of bus and car traffic. Auto traffic is projected at 43 to 53 percent of total passenger travel. Putting this into the perspective of an expected increase in total travel by a factor of three, this means that auto travel will grow by a factor of 2.5 to 3 while high-speed travel increases by a factor of 6. Based on expected kilometrage per automobile, this anticipates more than doubling the size of the automobile fleet by 2020, but the faster modes will increase more rapidly.

This perspective is another way of conceptualizing the constraints on auto mobility in the future. It does not isolate the situation of the developing world, but it infers that the balance in growth of motorization will increasingly be in the developing world.

In summary, the projection of motorization with reference to the developing world is a very difficult task at which the work has offered certain interesting insights but is a long way from confident estimates for the future at the level of 20 years and beyond. It has attempted to cope in various ways with the perception that such rapid increase has eventually to attenuate in some form, but it has presented as yet no persuasive view of altering trends.

SPARKS OF MOBILITY LEADERSHIP FROM THE DEVELOPING COUNTRIES

Even though there is much less R and D on mobility in the developing countries and public budgets are limited, they have certain important advantages in mobility innovation. These include some cases in which there is:

1. Stronger authority behind mobility actions. There are countries in which urban governments have much more authority than in the developed world (often because they are single governments rather than balkanized into a number of local administrative units, and sometimes on account of vested authority). Some countries have more power in central government guidance of local action, particularly in the case of a capital-megacity, In a few cases there are remarkable levels of charismatic leadership, such as Jaime Lerner of Curitiba, and Ronald McLean Albaroa of La Paz.

2. Lower personnel cost relative to capital costs. This simply results in different choices of actions, sometimes with consequences worth the attention of wealthier countries.

3. Fewer regulatory and legal barriers. These permit the introduction of guidance that would be halted in the developed work by e.g. fear of suit in the case of malfunction

4. Less convention in problem solving. In countries where transportation planning is a professional tradition thinking is more conventional and there may be less scope for innovation. Innovation is sometimes easier in a less structured professional environment.

5. More severe problems to overcome. Congestion is worse on average in cities of the developing world, because motorization is taking place at rapid speed without time for adaptation. As a result, these cities have a higher stake in solving mobility problems.

6. Perceptibly growing problems. In many developing cities congestion is growing at a rate easily perceived year to year by even a casual observer. Any observer over 40 years of age remembers when central Miraflores outside of Lima, or Providencia outside of Santiago were quiet semi-commercialized areas with stores in former houses. Now they are occupied by 20 story buildings surrounded by massive congestion. This public awareness is leverage toward action in some cities.

There are cases of leadership in a number of categories. These are innovations, existing or incipient, that are native to the developing world.

1. <u>High yield vehicle use restrictions</u> Responsive to the severity of the problems, cities of the developing world often reach for higher achievement actions than developed cities. It is not unusual to have serious discussion or even attempts at implementation of actions that are almost patently impractical. For example, Bangkok made a recent serious effort to restrict all newly registered cars to use exclusively in non-rush hours.

Perhaps the most stringent restrictions have been imposed in China by municipalities concerned with mounting congestion. Some of them have limited the number of new motorcycle registrations each year. In Guangzhou it is not lawful to enter the city on a motorcycle registered anywhere but in Guangzhou. Many of them have limited the operation of commercial vehicles in unprecedentedly detailed ways (in terms of days, hours and localities). At last notice these restrictions had not affected private cars.

Some high yield restrictions have been associated with very high pollution levels. Restrictions in Santiago and Mexico City to limited days a week and limited parts of the city have emerged from this problem.

2. New technologies. Cities of the developed world have experimented with untried technologies. Brazil has been the first to build a substantial number of transitways. Systems have also been built in Instanbul, Ankara and Abidjan. The air propelled aeromovel has been introduced only in the developing world (Sao Paulo, Porto Alegre and Jakarta). In La Paz, Mayor McLean Albaroa has advocated teleferic for new hilly transit routes and may soon be successful. Altogether, however, given current opportunities for private participation in infrastructure there is rather less innovation in developing cities than one might expect.

3. Privatization of existing highways. Certain countries have taken special initiative in the privatization of maintenance and extension of highways. It has been found a difficult job and there have been costly errors. these have included preparations that attracted insufficient bidders and excessively rapid pay-back schedules that produced very high tolls. But the efforts have generated valuable experience and may lead the way toward more general practice. Mexico, Argentina and Colombia have been particularly active in this matter. Other Latin American countries such as Chile, are following suit, in that case with the division of the Pan American Highway into several lengths for privatization. The Chilean government is adding the innovative dimension of contracting economic development services at the same time to convert the highway into a more significant development generator, at the same time, of course, creating market for travel on the highway.

In the construction of new highways there has been much activity engaging the private sector in the developing world for private toll facilities, BOT and other arrangements. While not originated in the developing world, the level of commitment to this form of new highway development may well exceed kilometrage in the developed world. Significant activity is taking place in India, Philippines, Indonesia, China (in Guangdong), Thailand, and elsewhere.

4. Private non-unitary transit management. The vast majority of public transport systems in the developing world are private and always have been. Most of them are made up of relatively small scale concessionaires each serving a limited number of routes and in some competition with one another. There is often a separate public transit authority serving a small portion of the demand. The management of transit is often a lively debate with cases of publicization of public systems as well as the privatization of public ones.

As a result, while not innovative, the competitive environment of privatized transit in much of the developing world provides a laboratory of experience in the management of concessions and other contractual arrangements for private service to the public under circumstances of competition among servers. Several cities have tried a number of alternatives, dramatically represented by the deregulation and reregulation of public transport in Santiago.

5. Transit innovation. There have been innovative ideas such as several from Curitiba: the platoon system of grouping buses, the tube station enabling prepayment of the fare, and the practice of providing transit tokens for turning in a bag full of street trash. Brazil offers the experience of employer-provided transit passes.

Perhaps the most useful experiences in this category have been those of flexible transit use under circumstances of permissive or sometimes unenforceable transit regulation. Routed vans and cars often switch to the role of taxis when business is slack and opportunity occurs. There is a variety of experiences with informally revised (i.e. unauthorized) transit routings for example to escape unprofitable congested streets at the city center through route terminations at the periphery of business districts. There have been informal resolutions of low volume service needs at urban peripheries and after hours requirements.

6. Assertive Congestion Pricing and Other Ownership/Use Charges As means of controlling mounting congestion high user charges are recurrently considered in many countries of the developing world. The examples of Hong Kong and of Singapore (where purchase taxes amount to some 300 percent of the price of the vehicle) are present examples. There have been temporary cases of high user charges in various countries, for example in Chile during the regime of the Unidad Popular in the early 1970s, when automotive imports were very heavily taxed, and in Korea during its period of rapid industrialization. Area licensing schemes resembling Singapore's have been repeatedly proposed, for example in Bangkok and in Kuala Lumpur. So far, no very assertive policy of pricing has appeared on a long-term basis in the lower income countries, but it remains a possibility as concerns rise and the dialogue continues.

7. Rapid Transit Innovation There is incipient possibility of changing views on rapid transit in the developing world, especially resulting from an alteration of the position of the World Bank. Up to now the position of the international community has been reluctant, or outrightly opposed, to nearly any investment in rail rapid transit on the grounds of its high capital cost and need for high operating subsidies. This is understandable since the only metros that current recover their operating costs are Seoul, Santiago, and Hong Kong. Only Hong Kong covers full costs and is a very special case in various respects (e.g. 50,000 people live within 10 minutes of each stop, and a fare of over US$1 is feasible). Even the widely tauted high volume of use of the Mexico City subway yields only 40 percent of operating costs from the fare box.

However, now that there are over 14 rail transit facilities in the developing world with some twenty years of record, it has become evident that

cities with metros have better preserved and developing centers than others, and that a capacity up to some 70,000 passengers/direction/hour has enabled the full networks of urban transportation systems to work much better than otherwise. These benefits are impossible to evaluate with any satisfying precision, but the visible evidence is persuasive.

This has led the World Bank to issue a surprising discussion paper, "Approaching Metros as Potential Development Projects" (March, 1997) by Slobodan Mitric. This paper represents the prospect of an entirely new discussion in the Bank. Whereas Bank transport policy up to now has been that metros are reasonable only in very exceptional cases when they are "likely to produce high rates of return," taken to mean virtually never, this new paper sustains the position that

> "...neither the state of the art of economic evaluation of metro projects nor its quality as practiced by consultants working in the developing countries are strong enough to justify treating the assessed economic rate of return as both a necessary and sufficient condition for project acceptance. It is simply too narrow, doing injustice to the complexity of the subject of cities in developing countries and their strategic decisions in the transport dimension."

The final section of the paper reads like a design manual. It is difficult to say what impact this may have on the substantial number of cities in the developing world that recurrently debate the possibility of rail rapid transit, but it appears that encouragement might conceivably be in store.

8. Auto Cooperative Possibilities. The movement toward car sharing so far shows little evidence in the developing world, but there are grounds for regarding it as a hopeful possibility. Here are some reasons:

--In many of the more advanced developing countries there are significant populations with substantial incomes just under the threshold of auto ownership, with reasonable credit records and who share the world view that includes auto mobility.

--The practice of sharing assets in general is a growing practice universally, and the developing countries are part of the trend. The trend may well be based, more than anything else, on institutional and telematic developments. That is, it is now possible to negotiate and enforce more complex contractual agreements than formerly. Some countries are improving systems of these kinds. Further, in the developing countries' typically higher density cities there is considerable sharing of common building spaces and utilities connections. There is also sharing of vacation houses and work equipment (especially in fishing and agriculture). In some cases higher risks of breakdown and service interruptions have encouraged sharing agreements for back up services.

--The issues of maintenance are surely a concern in auto cooperatives. This is a situation in which the relatively lower costs of labor in the developing world are significant. In many countries it would be practical to have a chauffeur capable of minor repairs permanently assigned to a particular car who would work in turn for its various users.

9. Institutions for Credit Purchases The lack of credit to purchase vehicles has been a limitation throughout the developing world. There are, however, special institutions that have been used to overcome this problem. There are several countries with special national funding for the replacement of vehicles in the public service. In Colombia there has been a Corporacion Financiera de Transportes making low credit loans for the replacement of buses, taxis and other vehicles that serve the public. A similar one has existed in Venezuela.

10. Land Use Planning as a Mobility Tool Transportation and land use planning has a checkered history with limited achievement in the high income countries. This has been a consequence of limited metropolitan public powers, the need to accommodate varieties of stakeholders, and a limited need for such action in the eyes of responsible officials. There are indications of greater possibilities, however, in parts of the developing world. There are indications of this effect in the success of Korea in imposing development restrictions that have clustered demand around Seoul, special land assembly in Shanghai and Bombay, new cluster development in Bangkok, and other cases.

Reasons for the promise of transportation-friendly public action in land development include:

--High levels of public authority in the metropolitan areas of certain countries. In China the government owns the land, leasing it to private or public users through municipal district action. In Singapore government owns a large proportion of urban land (in fee simple). In Seoul, a mayor of the city reportedly created a scandal ultimately terminating him in office when he attempted simply to extend a dwelling he owned in a green belt. In Bangkok the governor was able to focus his authority on sites where transformation was desired to create a submetropolitan center for future development. This does not ignore, of course, that land development control in most developing countries is very weak.

--The speed of urban development promises significant effects in limited time. At typical rates of 5 percent per year, new urbanization that doubles the population of the existing city is created in only 14 years. Since much of this new population is at decentralized locations on new terrain, it is an opportunity for urban development planning.

All these items represent possibilities for coping with rapid motorization on the part of the developing world by means that are not directly borrowed from the developed countries. They may also be approaches that bear watching from the vantage of the high income countries. Probably the most promising initiatives are congestion pricing, other traffic management techniques and land development planning.

BORROWING FROM THE DEVELOPED COUNTRIES

There is a pervasive belief in the developed world that we have much to teach the developing world about mobility and motorization. Holders of the this belief include people with contradictory different opinions. There can be

little doubt that this statement is certainly true in some sense, but its interpretation is bound to be controversial.

Let us divide lessons to be learned from the developed countries into three parts:

1. Lessons of technology. It is simply a fact that the vast majority of R and D dollars are spent in the developed world (and for it). The developing countries are mostly borrowers of technology and some guidance would be in order.

2. Lessons of institutional management. The public and private sectors in the developed world have tried a number of things that don't work in administering public transport, managing vehicle use and so forth. This experience may be sufficiently basic that it could enable new managements to save costs and trouble.

3. Lessons of general experience. The urge to convey wisdom from past experience emerges from a belief that the developed countries have been along a path of mobility evolution on which the developing countries are coming behind. Accordingly they should learn from our errors, and our lost opportunities. This is the most complicated element of lessons to be learned. For one thing, it is not clear that the path is the same one. For example it was one thing to accompany the invention and industrial development of the automobile, and another to adopt it in later stages. Further, it is often not clear, or entirely shared, that the errors were in fact errors, or that the untried alternative would in fact have been better. And indeed, it is often not clear that the conditions criticized could have been, in any case, avoided. Finally, since these problems are often the by-product of a much-sought life style, recommendations sometimes bear the image of paternalism or even hypocrisy.

Let's look at some of these possibilities more closely. First, lessons of technology and technological loan possibilities. They include devices to reduce engine local pollutants, and global warming emissions. They include new low cost vehicle technologies, ITS equipment, and transport infrastructure designs such as transitways. The lessons and lending issues are straightforward in this category. There might be some concern for the substantial extent to which this lending is of technologies created for the developed world, rather than for the developing world. There have been recent moves toward targeting the needs of poor countries, especially through low cost vehicle development. There are surely a number of uncovered possibilities.

The lessons of institutional management are also very good possibilities to facilitate mobility in the developing world. These are topics on which the developed countries have demonstrated capability, often learned through decades of trial and error. Items in this list are also restricted to those that are relative non-controversial. Among the possibilities:

--Control of expenditures in the light of probable revenues and available budget. Transportation projects all over the world classically underestimate costs and overestimate receipts, resulting in serious financial problems. (This is particularly problematic in the liberalizing planned economies, where systematic concern for the matter is not a strong part of their project administration background.) Learning on this problem is better characterized as a world-wide comparative experience, rather than a

developed/developing country exchange. It is the case, however, that the problem is better documented in the developed world and refined techniques for cost and revenue estimation are more available from the developed world. This point is one way of introducing the whole subject of transportation systems planning technique, generally a useful contribution uncomplicated by controversy, and learnable as a set of skills. (Note that for the moment we ignore the process of transportation planning, which is in a different category.)

--Better privatization is a topic closely related to the last one. It is a second case of worldwide learning (with many of the important lessons coming from developing country experiences). It is nonetheless constructive for the developed community to convene the effort, bringing into play the considerable research that has been done on the subject.

--Traffic management techniques, including the institutionally complex issues of implementing ITS, is another potentially important contribution. Part of the challenge on this matter is assuring that the techniques installed respond to the serious needs of the developing world for high yield actions, rather than installing systems more characteristic in developing cities that are focused on minimal institutional and behavioral dislocations.

--Transit administration is an important possibility. While the developing countries have more presence of public transport, their public management systems or transit are often poorly functioning concessionary systems that remain from the sector's early times and are not adaptive to contemporary scales of big city needs.

--Beyond this are numerous administrative practices ranging from vehicle registration systems to enforcement and educational needs in which the transfer or adaptation of management schemes would be very beneficial.

Lessons of general experience are the most complicated group, learning from the problems that have resulted from the whole overall prevalence of motor vehicles in the developed world. At one level we can pessimistically suggest that if the developed countries did not learn sufficiently to solve their problem while it was being created in their own environment, how can we expect a response from citizens of a country that has not experienced the consequences yet. Further, in many cases the balance of advantages and disadvantages is such that final judgments about painful restraint behaviors during rapid motorization is subject to varying citizen values.

The emphasis here should be on descriptive analyses of experience that are as value neutral as possible and which encourage independent decision on the part of developing country governments and private participants. They need to illustrate both the advantages and disadvantages. Such demonstrations have to relate to the experience of the listener. It is one thing to study problems in cities where dislocations based on rapid motorization are already taking place (Bangkok, Cairo...), and another to discuss them where such changes are only incipient (Colombo, Tashkent...).

CONCLUSIONS

Cities of the developing world are dramatically dfferent from one another, but they share certain characteristics and problems that distinguish them from the mobility settings of the developed world. Most of them suffer more serious existing and impending problems of mobility than their counerparts in the developed world. At the same time they may have, in some respects, better chances of significant actions to solve them.

Endowments of public services are more uneven, giving rise to difficult decsions about the allocation of resources. Endowments are very different from one public service to another. In the developed world we deal with transportation as the malfunctioning subsector in a context of virtually complete service in the others--power, sewerage, water... Endowments are very unequal among parts of the population depending on location and automobility and will be for some time to come. This is different from an almost completely motorized population.

At the same time motorization is a powerful force toward economic development, an urgent concern of the developing world that has receded to lower priority in developed cities.

The dynamic of urban development is very different. Rapid motorization and urban population increase is a demanding setting for mobility management, but at the same time provides important oportunities for problem solving that are not available to more settled environments.

The possibilities for achievement reside in policy makers' firm acknowledgement of the threats to economic growth and quality of life presented by the path of change in mobility. The stakes are high. It is essential to take avantage of the strength of public policy, and to enhance it forcefully where necessary, in order to take the high yield actions required. These actions must induce socially responsible use of motor vehicles so that the broadest possible advantage of improved mobility is available to the population and the economy without permitting an unsustainable use of motorization to block its own path. They must induce a form of urban development that enables the preindustrial city to cope with the arrival of new technologies, including the phenomenon of motorization, and at the same time, serve the needs of cities with much to recommend their current compact structures and a population that will be without motorization for a long time to come. And they must invent forms of investment that provide a sustainable stream of resources into the infrastructual part of the solution.

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