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URBAN TRANSPORT

World Bank

<u>Sector Policy Paper</u>

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INTRODUCTION

It may be useful to place this paper on urban transport in a somewhat broader context.[1] It is customary to treat the rapid spread of urbanization as a critical problem for developing countries. And this is of course so. The appalling conditions in the major cities, particularly in their poorer districts, are familiar. So is the severity of many of the urban transport problems with which the paper deals. More fundamentally, it is evident that growth rates of urban population, exceeding 4% overall and more than 7% in many large cities, conflict with the shortage of resources available to meet the costs of urban expansion.

Rapid urbanization, however, deserves to be considered not only as a problem, but also as a solution, as a way of absorbing productively the growing totals of rural labor that are surplus to the requirements of agriculture. Few people 25 years ago would have dared predict that the cities could possibly absorb so much additional labor as in fact they have—in jobs where productivity may be very low, but on the available evidence is generally higher than in the case of marginal rural labor. The deficient living conditions of the urban poor, though more visible than those of the rural poor, are nonetheless a distinct improvement for most migrants.

In this context, urban development and rural development complement each other; and the potential role of urban transport in coping with rapid population growth is accentuated. Urban transport can provide the mobility and accessibility needed to integrate newcomers into the urban economy, thereby indirectly helping to relieve the pressures of surplus rural population on rural poverty.

As the paper shows, the reduction of costly inefficiencies in transport, and the correction of misguided priorities, can particularly help the urban poor, promoting equity as well as economic efficiency. The paper also brings out that new physical urban patterns will inevitably be required to absorb the much larger urban populations of the future. In this respect, the development of transport networks can be a major influence in providing the enlarged populations with both more efficient and more livable towns and cities.

The importance of this positive aspect of urban development becomes more evident in the light of the latest population projections

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[1] *All references to the World Bank in this paper are to be deemed to refer also to the International Development Association, unless the context requires otherwise. The fiscal year (FY) of the two institutions runs from July 1 to June 30.*

made by the United Nations.[2] Taking its medium forecast, in the next 25 years twice as many persons as during the last 25 years will be added to the urban population of the developing world. This increase is dramatic: urban populations in Africa rising from under 100 million now to over 300 million by the end of the century; in Latin America from under 200 million to over 450 million; and in South Asia from well under 300 million to over 800 million. By the turn of the century, India may have more than 20 cities of over a million inhabitants, while Latin America can be expected to have a higher proportion of urban population than Europe has today.

These estimates are unavoidably rough, and the detailed assumptions can be challenged. But given the inevitable time lags in changing major trends, it seems unlikely that migration and urban growth will be very substantially slower than projected, at least over the near term. Indeed, the U.N. report implies that the pressures toward urban growth may, if anything, be stronger. Despite the migration to the towns, the rural population is still projected to grow rapidly. In the next 25 years, as many people will be added to the rural population in Africa and South Asia, as to the urban. But as the U.N. report points out, pressure on land is already severe and extension of cultivable area is becoming much more difficult. In South Asia, it is estimated that the agricultural population already averages 230 persons per square kilometer of arable land, compared with 60 in Europe and five in North America; yet a further increase of more than 50% in the rural population is projected for the next 25 years.

In this perspective of the necessary role of urban development in absorbing a large part of the overall increase in population, the importance of urban transport contrasts sharply with the relative neglect of the policy issues involved and of feasible solutions. On present trends, the cities of the developing world risk to repeat, and in an exaggerated manner, the shortcomings of urban transport and urban physical patterns of the cities of the developed world.

The paper is purposely tentative in regard to both its conclusions and the scale of the programs recommended. Surprisingly little is known about analyzing the long-term implications of alternative urban transport strategies and investments; and the effort required for widening the framework and scope of urban transport projects is very large.

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[2] *United Nations,* Concise Report on the World Population Situation in 1970-1975 and its Long-range Implications, *July 1974, Sales No. E.74.XIII.4. Urban data are based on national definitions. In this context, "South Asia" includes the Indian subcontinent, Indonesia, Malaysia, the Philippines and Thailand.*

But these limitations should not mean that action is inhibited. To take an example, and one that is not exaggerated, it may be found that a third of the buses of a bus system are out of service at the beginning of the day, and a third of those that take the road break down during the day; that waiting times at busy terminals average three-quarters of an hour or more; or that transport management, traffic officials and urban planners rarely, if ever, meet. In such circumstances, it does not need a superior methodology to devise projects and associated policies that could produce major benefits and high rates of return—even if all the implications cannot be traced, and even if further adaptations are required later. This does not, of course, mean that such projects are easy; there are many institutional and sociopolitical obstacles. But the more proficiency is gained in the nuts-and-bolts preparation of such projects, the more time and opportunity will be available to develop methodology and to produce evaluations of increasing depth.

SUMMARY

The importance of urban transport lies fundamentally in its contribution to the large economies of scale and specialization associated with urban growth. Though only about one-quarter of the developing world's population is urban, typically more than half the national output is produced in the towns, mainly in the major cities. Urban transport is not only essential to the requisite concentration of employment and production within urban areas; it also provides the necessary links with the transport network serving the hinterland. From a wider viewpoint, the transport facilities expand the options for work and give access to health, educational and other amenities which, because of scale economies, can often be effectively provided only in urban areas. Provision of minimum transport inputs for these various purposes within the very limited resources available is the basic problem of urban transport in developing countries.

There is, however, another aspect of urban transport which accentuates the basic problem of shortage of resources in developing countries. A large proportion of expenditures on personal travel, the largest component of urban transport, is for additional comfort, convenience and saving of leisure time above those provided by the minimum transport levels available. To this extent, urban transport is akin to other consumer goods and services rather than just an intermediate product or an input into production to be provided as cheaply as possible. It is where the provision of such additional personal convenience in transport conflicts with provision of basic transport inputs for essential purposes, including not only commercial and public transport, but also pedestrian and cyclist traffic, that the most difficult policy issues arise.

Urban transport and urban physical form are closely related. Physical urban patterns greatly influence the relative merits of different transport systems; urban transport facilities greatly influence the development of physical urban patterns. Though other influences on urban form and urban transport such as provision of public utilities and industrial sites or land use policies are also important, the links between urban physical patterns and urban transport are so close as to merit their being considered together. That the potential for influencing urban form purposely rather than haphazardly has been little used makes it no less desirable to conceive of urban transport in the role of promoting urban patterns that are economically efficient and enhance standards of living.

The Current Situation and Prospects

The current situation of urban transport in the developing world is alarming. Despite still low levels of private automobile ownership, congestion in the cities is already severe in degree, in daily duration and in size of areas affected. Public transport is inadequate both in levels of service and in the areas served. The fact that a large part of the population of the poorer cities cannot afford any form of motorized transport underlines the seriousness of reductions in facilities for pedestrians and cyclists in meeting the requirements of other traffic. Commercial transport suffers heavy expense from severe congestion, poor road surfaces and inadequate terminal facilities. Contributing to these deficiencies are often low proportions of urban area devoted to roads, the mix of slow and fast vehicles, and patterns of built-up areas that hamper traffic flows.

Underlying the severity of the urban transport problems of developing countries is their acute shortage of resources. Provision of expensive long-life urban transport infrastructure sufficient to match the large additions to population is proving impossible despite allocations that are often the largest item in, and sometimes take over a quarter of, public budgets for urban areas. High foreign exchange costs of private automobiles are a salient feature of overall resource use, a feature which is being amplified by current motorization trends and the rise in fuel costs.

A rapid deterioration in urban transport conditions in developing countries is in prospect, if present trends are allowed to continue unchecked. Current exceptional rates of urban growth are unlikely to diminish in the near future and may well accelerate. Moreover, as towns grow and workers live farther from their work, a more than proportional expansion of transport facilities is required. Demand for road space is accentuated by higher incomes which enable more people to travel by bus instead of walking, and more to afford private automobiles in place of public transport.

The high rate of growth in demand for urban transport which is to be expected is made more serious by inherent tendencies toward increasing costs of supply. Additional road capacity in congested central areas can only be provided at progressively higher expense. This also means that, for any given road use policy, an intensification of congestion must be expected; a greater degree of congestion will need to be tolerated before the benefits rise sufficiently to justify the higher road construction costs.

Increasing congestion raises vehicle operating costs and also personal travel time and discomfort. Due to the high element of labor in costs of commercial transport, heavy expenses are incurred as delays increase. Buses are particularly adversely affected as compared with automobiles, even though in terms of passengers carried they use much less of the expensive road space. At very high levels of traffic density, mass transport on separate rights-of-way may become the most economical method of expanding personal and total transport capacity. Where subways are involved, however, trip costs will generally be well beyond the ability of the poor to pay.

The cities of the developing world are accordingly faced with a conflict between the benefits of the increased productivity and amenities to be derived from continuing concentration of production and commerce, and the rising costs of expanding urban transport sufficiently for these benefits to be secured. Put another way, unless new approaches to the urban transport problems are adopted, the improvement in output and living conditions which should be associated with the rise in urban population will be jeopardized.

Possibilities for Improvement

Fortunately, possibilities do exist for combating the threatened deterioration in urban transport if strong action is taken in three interrelated fields. Firstly, more rational use of transport facilities, particularly of road space in congested areas, must be ensured. Secondly, large improvements are needed in the efficiency of transport undertakings and their coordination. Thirdly, transport requirements should be considerably reduced by closely relating transport facilities to improvements in urban physical patterns. Great opportunities for effective action in these three fields are provided by current low levels of motorization, the large potential for management improvement and the rapidity of expansion of urban areas.

Rationalizing the use of transport facilities: The worldwide strength of demand for private automobiles reflects the great convenience and the expanded opportunities they provide. These benefits should not be unnecessarily forfeited; but neither should they be provided at the expense of the less fortunate majority of the urban populations. At present, extravagant use of road space per passenger by private cars imposes heavy costs of exclusions, delays and discomfort on other road users that are not adequately reflected in the charges made for use of congested roads. Charging for peak-hour use, similar in principle to the higher charges made in some countries for peak-period use of telephones, is needed. Such pricing would eliminate vehicle trips, the benefits of which are valued at less than the costs inflicted on others. Appropriate charges for use of congested roads during peak periods might amount to upward of $1 per vehicle a day. Economic charges for parking would also be above present levels. Road user charges should also cover environmental costs, such as air pollution and noise, inflicted on others.

Difficulties of introducing appropriate congestion pricing are both political and technical. The political problems are severe for decision makers dependent on car-owner support. Technically it is difficult to design systems without serious drawbacks such as heavy trip restraint at times and places where spare transport capacity exists. Supplementary monthly or daily licenses for use of central area roads during peak periods and heavier parking charges seem essential ingredients of a feasible charging package.

Early and progressive action is needed if the rapid rise in automobile ownership is not to intensify the political difficulties. Failing congestion pricing, supported by physical measures discussed below, the only effective way to achieve more economic levels of road use will be to restrict automobile ownership by higher general taxes and/or quotas. This second-best solution involves unnecessary and severe restriction of automobile use on uncongested roads but may possibly be favored from fiscal considerations.

More appropriate pricing of congested road use can alleviate, but cannot be expected to cure, congestion. Even with much higher charges than at present, the latent demand for more road space in the cities of developing countries, the speed of urban expansion, and the basic shortage of resources, ensure that the number of vehicles will soon catch up with the road capacity released by better pricing.

The importance of congestion charging lies primarily in the change produced in the traffic mix in favor of public transport, commercial traffic, and lower-cost forms of private transport, thereby increasing the number of persons, particularly poorer persons, carried. Charging of economic prices for the use of congested roads also reduces misallocation of resources by lessening the pressures to purchase and run private vehicles for uneconomic trips, to construct expensive urban roads and to develop urban sprawl.

Highly skewed income distribution and large uncharged "externalities" create a need to supplement congestion charging by administrative action and physical restraints if the transport functions most essential to the efficient running of cities are to be adequately provided. Staggering of work hours can help spread the peak load. Through traffic using central areas can be diverted by physical barriers to longer but less congested routes. It is also often practical at low investment cost to increase road capacity significantly by better signals, one-way streets, parking prohibitions, and other measures of traffic engineering and management. It is surprising how frequently such possibilities are neglected in favor of much more costly road expansion.

More direct action is also needed to establish priorities for essential transport, and particularly for low-cost, high-volume public transport to carry workers to their employment. Specific physical measures are necessary to shield buses from the interference and delays caused by other traffic. Methods include reserved lanes or streets in highly congested areas for buses and other essential vehicles, priorities at intersections and access points, and facilities for quick bus turn-round at terminals.

Recognition that in developing countries pedestrians and cyclists typically account for the majority of all urban trips has important implications for traffic management and urban transport system planning. In the poorer developing countries large sections of the urban poor will continue to be unable to afford motorized transport of any kind. The domination exercised by motorized transport, and reflected in curtailment of sidewalks, needs to be curbed. Closing some central area streets to vehicular traffic at peak periods merits serious attention. Of the greatest importance in its potential for cheap, and relatively fast, high-volume transport, is the provision of separate tracks for cycles and motor-assisted cycles.

Management improvement and coordination: Improvements in efficiency of transport undertakings and their coordination are heavily dependent on better management. Standards of public transport service in terms of speed, comfort and fares need to be tailored more closely to income levels. The poorer the travelers, the greater the importance of the level of fares relative to time and comfort. But enforcement of low fares by regulatory authorities is not, by itself, generally conducive to efficiency. The consequent lack of financial resources often indeed results in obsolete vehicles and inadequate maintenance, leading to high rates of breakdown and poor service. A more direct attack on costs and standards is required. So is action to remedy inefficient regulating methods which, combined with management weaknesses in municipal bus companies, are reflected in the failure to develop new routes.

Specific subsidies for public transport may be justified in some cases, particularly where conditions of decreasing unit costs prevail and alternatives would be more expensive. But other pressing calls on public finance and the very high cost of even a small subsidy per passenger, most of whom are not from the poorest groups, argue against general subsidies. So do the dangers of supporting management inefficiency. When capital for expansion is a major problem for private bus companies and smaller municipal undertakings that are otherwise financially viable, development of financial intermediaries deserves consideration.

The wide gap between levels of bus service that the poorer population can afford and those of the private car makes the provision of intermediate levels of personal transport, such as minibuses and shared taxis, more important than in developed countries. Regulations which hinder the development of such services frequently stand in urgent need of revision. The impact of additional types of service on the existing systems of public transport requires analysis, however, on an individual city basis.

Roads, ports, airports, individual bus routes, railways, markets and other parts of the transport system are generally run by separate agencies. Responsibility for municipal transport services is divorced from that for corresponding intercity services. Consideration of the urban transport system as a whole is consequently generally lacking. The advantages of coordinating local bus and rail routes and ensuring adequate links between urban and intercity commercial and passenger services are obvious. Unfortunately, independent action often fails to overcome the obstacles to such links.

Considerable scope exists for making the various measures of reform self-reinforcing. For example, congestion pricing of automobiles will be more acceptable if accompanied by improved services of shared taxis. Bus priorities are unlikely to be effective unless accompanied by other measures of traffic engineering and management. Fare increases may be best timed to coincide with improvements in service.

Institutional frameworks vary too greatly to permit valid generalizations on appropriate institutional forms for securing the requisite coordination. Monolithic transport authorities involve dangers of overcentralization and overregulation of operations. Transport planning units, if set up near the centers of decision making, should be able to resolve the value judgment issues necessarily involved and secure the authority needed for implementation.

Relating transport to urban form: The rapid expansion of urban areas and flexibility in employment location provide great opportunities for less transport-intensive, less costly, and more efficient and congenial urban patterns. Current policies and investment programs are implicitly based on questionable assumptions that existing traffic flows are rational, that efficient alternative locations for offices and other work places do not exist, and that single concentrated central business districts are viable and inevitable. There is no simple solution to the question of the best urban pattern, since local conditions and functions of cities vary so greatly. But various considerations strongly suggest that alternative urban structures could with advantage be adopted.

The most important of such considerations is the desirability of locating workers and their work in close proximity. The poor cannot afford either long distances or high rents. The urban structures should allow commercial traffic to avoid congested areas and promote public transport efficiency. More generally, the need to economize resources points to maintaining higher population densities than in developed countries. The resulting smaller urban areas will require fewer streets and provide greater access with fewer motorized trips, lower vehicle speeds and hence lower road and track design standards. Possible negative effects of high densities, on building and sewerage costs, for example, must also be taken into account.

Such considerations point to advantages from city structures encompassing several secondary employment centers and a greater mix of work places and residences than found in the cities of developed countries. Reduced average trip lengths, more balanced traffic flows and high densities along public transport corridors are among the potential benefits. Important economies are also possible in the layout and road standards of local neighborhoods.

Market forces will not by themselves produce desirable urban forms largely because land and transport prices do not adequately reflect social costs and benefits. In these conditions, pressures to ensure continued accessibility tend to reinforce the dominance of existing business centers despite increasing costs and rents that force out residences. In the process, the transport system generally develops radially from the existing center with little stimulation of secondary centers.

To promote new activity centers with adequate levels of accessibility for businesses not strongly dependent on central city location requires secondary nodal points of the transport system and large initial infrastructure investments. Congestion pricing and other appropriate adjustments to prices and taxes can provide favorable underlying conditions. But it is also necessary to use transport investments to guide location, and to reform and simplify land use regulations. A less exaggerated pattern of rents and better mix of residences and economic activities in the old as well as the new centers should result.

The failure to grasp the potential of improved urban physical patterns has been accentuated by serious weaknesses of urban transport methodologies and models stemming largely from the intricacies of the urban transport networks, and the complexity of interactions with other urban services. These drawbacks are amplified by the unprecedented and largely unpredictable rates of change of the cities of developing countries. A shift in focus to clarify the main objectives and opportunities and to develop broad alternative strategies appears essential. Transport planning should be an integral phase of general urban planning.

A Bank Approach

The importance of the sector, both directly and in its impact on returns from projects in related fields such as intercity transport, ports, airports, industry and tourism, contrasts with its relative neglect. Many obvious possibilities exist for urban transport improvements which would both increase productivity and improve the position of the urban poor. It is indeed the urban poor who suffer most from existing distortions and inefficiencies. Furthermore, urban transport projects provide a natural point of entry into the wider aspects of planning and promoting urban forms efficient in both economic and social aspects. The inherent complexities and inadequate methodologies and information, however, dictate a pragmatic approach in which programs and policies are developed and adapted in the light of experience.

The World Bank has only recently taken an active interest in the urban transport sector. Long preparation times for projects—including the requisite understanding of the urban context within which the projects will operate—heavy staff requirements, and general lack of adequate expertise both within and outside the Bank, make it inevitable that the Bank's contribution in this field will continue to be constrained. The number of projects will probably not average more than two or three a year for some years to come. It is all the more important that the Bank's program be highly concentrated where experience will be most valuable and where wide demonstration effects will be achieved.

Policy considerations: Fundamental to the Bank's approach is the need to place the physical elements of urban transport projects in the context of policy measures, institutional development and management solutions. Willingness of the appropriate authorities to develop and undertake broad programs encompassing a wide variety of reforms to improve urban transport and to achieve more efficient and congenial urban physical patterns is hence a *sine qua non* for Bank support. Action to promote more rational use of road space is of particular concern. A flexible attitude will be maintained toward subsidy policies within the overall perspective of promoting economic, financial and managerial efficiency.

The practical difficulties of implementing reforms in the urban transport sector are fully recognized. Progressive application of policy measures and institutional reforms is generally indicated. Consequently, continuity of association is envisaged with cities in which urban transport projects are undertaken; support over an extended period may encompass several projects linked to a sequence of measures. To help plan and implement such a strategy, projects will frequently include an important element of technical assistance and studies to support further policy measures.

Physical components: The wide variations in physical conditions, resources and needs of cities, and in their institutions, require considerable flexibility in the choice of physical project components. Primary emphasis will, however, be placed on low-cost public transport providing greater access to job opportunities, and on facilities for commercial traffic, cyclists and pedestrians.

Rehabilitation and expansion of bus and urban rail systems will accordingly be a priority area including vehicles, maintenance, and repair shops and terminal facilities. Bicycle tracks and pedestrian facilities will also be strong candidates for support either separately or as constituent parts of wider projects. Projects centering on improved efficiency of commercial transport are likely to include terminals, markets and goods transit facilities.

Roadways may either form part of wider projects or constitute separate projects as, for example, linkages between intercity roads and urban networks, or roads to provide better access to port areas and new industrial locations. The emphasis in urban road projects will be on facilitating cheap personal transport and commercial traffic; financing of roads primarily benefiting automobile users is not contemplated. It is recognized, however, that private car owners may be among the beneficiaries of any major road expansion undertaken primarily for other purposes. Traffic engineering and control schemes are expected to offer good prospects for acceptable projects.

Bank participation in general urban development programs containing transportation elements will also be considered. Help to private and small municipal transport undertakings may be given through financial and technical assistance to support financial intermediaries.

Other activities: This effort will be backed by a continuing program of investigatory studies of urban transport requirements and transport/land use planning. In the development of more appropriate methodologies, the Bank will be prepared to assume a larger role than in the past in stimulating more rapid development of expertise in this field.

Increasing attention will also be given on a selective basis to urban transport impacts and requirements of Bank projects in other sectors such as ports, airports, industry, tourism and intercity transport. More generally, the relationship of such projects to problems of urban growth, including those of urban transport, will be increasingly emphasized in their evaluation.

Chapter 1: CURRENT CONDITIONS IN DEVELOPING COUNTRIES

To summarize the situation of urban transport in developing countries is difficult. Physical conditions, income levels, and economic and social structure vary greatly. Important exceptions to any generalizations must, therefore, be expected. Nevertheless, urban transport conditions in the larger cities, where the majority of the urban populations live, have enough in common to justify some broad characterizations. Transport problems in the smaller towns, those below 100,000 population, are much less critical due mainly to shorter trips and to much more limited levels of economic development.

Deficiencies of Urban Transport Systems

Levels of congestion: In relatively wealthy cities like Caracas or Rio de Janeiro, as in very poor cities such as Bombay or Jakarta, traffic congestion is chronic. In a disturbing number of cases, to judge by the frequency of stalled traffic, conditions on individual road segments have deteriorated to the point where additional vehicles reduce speeds more than in proportion, thus lowering the vehicle-miles produced on the road network in a given time period. In such conditions, average road speeds in central areas eventually level off at between 7 and 10 miles per hour; but the length of roadways seriously congested rapidly increases and periods of congestion lengthen. In Bangkok, Sao Paulo, Lagos and many other cities, peak traffic pressures now extend with remarkably little variation over periods of more than 12 hours a day.

What the traffic data do not reveal is the number of trips abandoned or transferred to much less convenient times as a result of the acute congestion. This suppressed or latent demand is undoubtedly large and growing. Because of this latent demand, possibilities of reducing congestion by either increasing transport capacity or by restraining existing users are limited.

The most alarming feature of current congestion is that it is happening while private automobile ownership is still low. As Annex 2 indicates, the degree of motorization is closely related to levels of income. The poorer Asian and African cities typically have fewer than two automobiles per 100 persons. In the much richer Latin American cities the number rises to around 10. Even such levels are far below the 20% or 30% customary in Western European cities, let alone the much higher levels of North America.

Private vehicle ownership, nevertheless, varies to a greater extent than can be accounted for simply by income or city size. With similar income levels, Tunis has almost nine times as many cars per 1,000 population as Seoul, where car ownership is exceptionally low, and Nairobi some 30% more than Tunis. The motorization ratio for Kuala Lumpur is not much less than for Buenos Aires, where per capita income is three times larger. Such differences persist even when the comparison is limited to cities of similar size. As in most other aspects, the data need to be treated with great care; licensing records frequently fail to account adequately for retirement of vehicles. The variations are, nevertheless, too large to be readily attributed to inadequacies in the data.

Differences in rates of taxes and import quotas obviously play some part in explaining these variations; but it is not possible to say how much since population densities, the adequacy of public transport, income distribution and many other factors also play a role. As Annex 2 indicates, import taxes vary from under 30% to over 300% and gasoline prices now range from under 20 U.S. cents per gallon to over $2. The virtual suspension of imports of private automobiles over several years has clearly been a major factor in the low motorizations ratios of Seoul, Taipei and Bogota. It is relevant that whatever the inconvenience caused, there has been no apparent adverse influence on economic growth; the Republics of China and Korea and Colombia have all been high in the league of rates of economic development.

Varying levels of car ownership are reflected along with other influences in widely differing proportions of private vehicles in traffic flows. Automobiles account for over 60% of vehicle traffic in Caracas but only about 15% in Madras. Even where private automobiles are only a small part of traffic, it cannot be assumed that their role in congestion is small. Private automobile use tends to be concentrated on peak hours when even small additions to traffic on crowded and narrow streets can have large adverse effects on other vehicles.

Public transport: Public transport[1] in the cities of the developing world is generally and evidently deficient. Inadequate capacity is reflected in long queues and extreme overcrowding during long periods of peak traffic. Waiting periods at bus stops in busy locations often average over half an hour and sometimes more than an hour. Particularly vulnerable in this respect are transfer points from one type of transport to another—from rail to bus, or from interurban

[1]*"Public transport" is used in this paper to cover modes of collective personal transport other than private automobiles. The undertakings concerned may be, and often are, private, e.g., private bus companies.*

bus to local urban services. Clearly, the public transport system is rarely conceived as a whole by those who supply the parts.

Less readily apparent is the failure to extend public transport networks in relation to urban growth. Squatter settlements, often accounting for well over a quarter of city populations, frequently lack any effective public transport service. Where, as is usual, squatters are located on the outskirts of the city, inadequacies of the public transport system and long journey times can effectively preclude participation in many employment opportunities and thus aggravate income maldistribution.

Of all public transport deficiencies, the state of bus services is the most prominent. Though constituting a small proportion of the total number of vehicles on the roads, buses typically account for about two-thirds of motorized trips and in many poorer cities four-fifths. Inadequate fleet capacities are accentuated by low speeds as a result of congestion and frequent breakdowns that in turn contribute to further congestion. More than a third of municipal bus fleets is often immobilized; poor servicing and maintenance compound the more basic problems of obsolescence.

Conditions on urban rail services, which are of considerable importance in many cities, particularly major ports, are no better. In Bombay, for example, railways carry more than a third of the public transport load. Almost always developed from old intercity lines, urban railways suffer from obsolete rolling stock which often is over 50 years old, poor track conditions and faulty signaling.

To some extent, deficiencies of bus and rail services are being alleviated by "intermediate" personal transport services. Communal taxis, auto-rickshaws, "jitneys," "peseros," "por puestos," "dolmus"

Table 1

Modal Split of Motorized Trips in Selected Cities

City	Automobile %	Bus %	Other motorized[1] %	City	Automobile %	Bus %	Other motorized[1] %
Kuala Lumpur	47	35	18	Hong Kong	22	55	23
Caracas	46	35	19	Mexico City[2]	19	65	16
Kinshasa	33	58	9	Bogota	17	71	12
Bangkok	29	59	12	Karachi	16	63	21
San Jose	23	74	3	Seoul[2]	8	89	3

Note: The data for this sector are generally weak and not closely comparable.

(1) Includes taxis, jitneys, etc.

(2) Rail services are also important.

Source: Annex 2.

and many improvised types of transport such as "mammy trucks" are based mainly on automobiles and minibuses. Over the last few years, they have assumed, where permitted, an expanding role for those whom the bus or urban rail systems do not adequately cater for and who cannot afford private cars. In Tehran, for instance, some 2,000 jitney-taxis running on fixed routes carry about 100 million passengers a year, compared with 700 million carried by buses. In Manila, "jeepneys" (shared jeeps) carry as many passengers as do buses. Their costs and fares, however, are generally somewhat above those of buses and a large proportion of the poorer residents consequently cannot afford them. In the richer cities, ordinary taxis may make a significant contribution. Though much fewer in numbers, their total of person trips per day may exceed that of private automobiles as, for example, in Mexico City.

Ridership of public transport and intermediate personal transport varies greatly even between cities of comparable size and income. As indicated in Annex 2, well over half of all motorized trips are by public transport in Kinshasa but only about one-third in Kuala Lumpur. Not only in many poorer cities, but also in some of the richer Latin American cities such as San Jose and Mexico City, the proportion of public transportation is two-thirds or more. Low rates of public transport use may, it should be noted, reflect either high levels of private automobile ownership or poor public transport availability, or incomes too low even to afford the public transport available.

Pedestrians and cyclists: Essential to an understanding of the urban transport problems of the developing world is the fact that a large part of the urban population, particularly in the poorer cities, simply cannot afford any form of motorized transport on a regular basis. Ten U.S. cents a working day—fairly typical of fares for two bus rides of two or three miles—represents about 10% of an income of $300 a year. Many of the poorer wage earners earn less than this. Nor can they generally afford such a high proportion of income for transport after meeting costs of food and other necessities for the family.

Not surprisingly, therefore, walking and cycling are even more important than public transport in terms of number of trips, though usually not in distance traveled. Most trips in most cities of developing countries, including travel to work, are made on foot or cycle. Though difficulties of ensuring comparability of data are great, it is indicative that in large African cities such as Kinshasa and Dar es Salaam as much as two-thirds of trips have been recorded as on foot. In many cities, particularly in India and Africa, cycling also accounts for a high proportion of total trips. In Madras, for example, a third of vehicles entering the central business district each day are cycles as are more than 25% of vehicles passing a cordon some 10 miles out. What is surprising is the great variation between cities of apparently closely comparable characteristics.

The facilities for walking are poor. In cities such as Singapore or Caracas, sidewalks have been extensively cut to make way for automobiles. Crowded bus stops increase the hazards. Pedestrian crossings are almost nonexistent. New roads are constructed without adequate provision for pedestrians. In some instances, pedestrians are forced to find their way on unpaved paths and along railway tracks, as in Bangkok for example. As a result, walking and crossing streets in many cities have become highly dangerous.

Conditions for cyclists are, if anything, worse than for pedestrians. In many cities, cycles outnumber automobiles, and, in some cities in the middle-income range, the same is true of power-assisted bicycles. But bicycle riding is increasingly hazardous. As a result, this cheap and potentially very important mode of transport tends to be grossly underutilized.[2]

Commercial traffic generally represents a much larger proportion of total urban traffic than in the developed countries. Exact proportions are difficult to establish as many automobiles are used partly for commercial purposes. The number of vehicles registered as commercial, typically about 20% of all vehicles—the proportion is higher in the poorer and is lower in the richer countries—is often an underestimate. Since daily mileage is greater than the daily mileage for private automobiles, their part in traffic flows is typically probably over 30%.

Costs of urban goods transport are generally high. Expenses are greatly increased by congestion delays, and by wear and tear of commercial vehicles due to "stop-go" conditions and poor road surfaces. In the poorer cities of South Asia and Africa, hand and animal-drawn carts are a substantial part of the total of commercial traffic. The growing difficulties for such vehicles and their incompatibility with motorized vehicles as congestion grows are very evident. Urban goods traffic by water is also significant in many port cities; here, too, expansion of traffic has often led to severe congestion.

Adding to the difficulties of commercial traffic, facilities for transferring goods between transport modes, for example from rail to road, or ship to road, are generally seriously inadequate. Warehouses and truck terminals for breaking of bulk are often rudimentary, their condition contributing to high breakage and pilferage losses. Poor market facilities also cause high costs. Not only is their capacity

[2]*A similar potential for cheap personal transport that exists in some cities but is usually neglected is the ferryboat service.*

usually overstrained but their siting typically contributes substantially to congestion and delays.

Contributing Physical Factors

Road space: The prevailing high degree of congestion, despite relatively low numbers of automobiles, is often attributed to the small proportion of urban space devoted to roads. Available data indicate that whereas in the cities of developed countries roads typically occupy 15% to 25% of total urban area and over 30% in newer low-density American cities, in the developing world the ratio often falls below 10% and ratios much above 15% are rare. Due partly to differing definitions, the evidence is not conclusive and needs in any case to be related to city size, larger cities tending to need a higher road ratio.

The mixture of traffic: There is no doubt that, particularly in the poorer countries, the wide variety of traffic sharing the limited right-of-way, and ranging at times from camels and bullock carts to the latest models of private cars, is a serious factor in congestion. The greater the pressure on road space, the more speeds tend to be reduced to those of the slowest moving vehicles; the potential of faster public, commercial and private vehicles is wasted. Often, pedestrians and market activities intrude on the road space even of major arteries. Effective road capacity is generally further reduced by extensive uncontrolled parking of vehicles of all kinds, and by ineffective signaling and other traffic controls.

Urban patterns: Physical patterns of cities often compound the difficulties. Central business districts are typically not so clearly demarcated as in the developed world. The main activity centers are, however, often concentrated in narrow streets prone to intense congestion. High densities of intersections, winding configurations and changing road widths reduce capacity further. Frequently, too, the major cities with histories of export-based economic development are located at river mouths, often on islands, where areas of water and marshy soil hamper development of efficient urban transport systems. Many of these cities, such as Bombay, Abidjan, Calcutta, Jakarta, or Lagos, are plagued by difficult communication between the combined port, manufacturing and central business district, and the rest of the city and hinterland.

The Pressure on Resources

It is, however, the rapidity of urban growth and motorization in relation to the acute shortage of resources that most clearly underlies the current urban transport difficulties of most developing countries. Over the last two decades, populations of the large cities of developing countries have increased at rates generally in excess of 5% per annum and frequently over 7%, doubling within 10 years. Private automobile numbers have risen even faster, the records showing over 10% a year growth for the developing countries as a whole, and 20% in some major cities—a spectacular rate even allowing for probable overestimations. Commercial vehicle registrations have risen only slightly less spectacularly.

Investment levels: Urban transport infrastructure is long-life and costly. Heavy immediate investment per head of additional population is required to maintain service standards. Resources have simply not been available on a scale adequate to meet the escalating demand even though, on the basis of meager evidence, over one-fifth of total public investment in city areas has frequently been directed to roads and other transport facilities.

Even higher levels of public investment in transport are contemplated in some cities. In Bombay, a recent study indicates planned rates of transport investment of $30 million a year, or 26% of projected public investment expenditures over the next few years. This allocation substantially exceeds those to other sectors including public housing, sewerage, education and health, and represents $200 per head on the additional populations expected during the period, or $5 per annum per head of the present population. Since average annual income is only about $200 per head and total municipal revenues about $10 per head, maintenance of such high transport outlays on a continuing basis must be considered doubtful. Yet in

Table 2

Growth of Population and Automobiles in Selected Cities
Annual Rate of Growth, 1960-70

City	Population %	Automobiles %	City	Population %	Automobiles %
Abidjan	11.0	12.7	Istanbul	6.0	12.2
Seoul(1)	8.5	22.0	Mexico City(3)	5.8	10.5
Lagos(2)	7.9	15.5	Bombay	3.7	8.2
Kuala Lumpur	6.5	11.3	Singapore(4)	2.6	6.7
Bangkok	6.2	12.0	Buenos Aires(5)	2.4	12.1

Note: The data for this sector are generally weak and not closely comparable.

(1) Figures for 1961-70

(2) Figures for 1964-69

(3) Figures for 1960-71

(4) Figures for 1966-71

(5) Figures for 1960-69

Source: Annex 2.

Calcutta, with still lower income levels, projected transport investment per head is even higher.[3]

To the totals of public transport investment have to be added private investment, particularly in vehicles and parking space, and ancillary investments such as gasoline stations and repair facilities. Costs of vehicle operation and road maintenance are in addition. Unfortunately, data on private expenditures are too scanty to be of much use. For the richer developing countries, however, it appears that private investment in automobiles in urban areas substantially exceeds public investment in urban roads and even more that in public transport.[4] Data on family budgets indicate that the share of transport in the expenditures of urban families rises with income from a negligible level to over 5%, with a large jump, frequently to over 10%, on purchase of a private car—an indication of the large benefits perceived.

Foreign exchange requirements: The most salient feature of foreign exchange requirements of urban transport is the generally predominant role of private automobiles. However, though large in relation to the limited number of persons benefited, the total foreign exchange cost of private automobiles is less than is often supposed. Including fuel requirements, a figure of not more than 4% or 5% of overall imports appears typical. As private automobiles are so heavily concentrated in the urban areas, this is probably a close enough estimate for urban automobiles.

Bus imports are relatively very small and in most cases cannot be separately identified in the statistics.[5] In terms of foreign exchange costs per passenger-mile, buses are clearly much more economical than automobiles. A bus costing $40,000 or 13 times more than a typical automobile, may average over one million passenger-miles a year or over 40 times the passenger-mileage of a typical automobile; the bus is also likely to run for more years. Comparison of foreign exchange costs of the vehicles alone, however, somewhat exaggerates the advantages of the bus. Foreign exchange costs of fuel per passenger-mile show less variation between buses and automobiles; the

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[3] *In Kuala Lumpur, for comparison, investments in roads and buses to 1990 recently proposed by consultants amount to $350 million, or $300 per person added to the population during this period. This is in the context of proposals to restrain private automobile use.*

[4] *A recent study of Bogota, for example, estimates transport at about one-third of total expenditures, both public and private, on urban services (including housing, education, utilities, health, etc.). Private vehicles comprise considerably more than half of the transport expenditures.*

[5] *Imports are often limited to chassis. The foreign exchange costs of bodywork, spares, etc., cannot be separately distinguished. Imports of commercial vehicles are generally much larger than for buses but urban use cannot be separated from use outside urban areas.*

heavy weight of standard buses compared with the light automobiles typical in the cities of developing countries largely offsets the difference in effective passenger capacity.

Many reasons for the limited foreign exchange requirements of urban transport in developing countries at the present time are, of course, to be found in the low level of urbanization and of automobile ownership as compared with developed countries. With much greater dependence on public transport, cycling and walking, the energy crisis and the rise in prices of fuel used in urban transport has so far had only a limited impact. The impact of higher costs of fuel for other uses has generally been much more significant. Current trends in levels of urbanization and motorization, considered in greater detail in the next chapter, make it probable, however, that foreign exchange costs of urban transport in developing countries will grow at a faster rate than can generally be expected for their national economies. The implications, both in terms of foreign exchange stringency and fuel conservation problems of urban transport requirements, may, hence, become considerably more important.

Chapter 2: THE PROSPECTS FOR URBAN TRANSPORT

Impact of Population Growth

If the present situation of urban transport in developing countries is serious, the prospects, if existing trends are allowed to continue unchecked, are even more disquieting. Dominating the outlook from the side of demand is the probability of continuing exceptional rates of urban expansion. Roughly half of the current growth in urban population is from natural increase; and in the short term, any decline in birth rates will probably be largely offset by declines in death rates. Nor is the flow of migrants likely to fall. Unprecedented rates of population growth in rural districts as well as in towns, and ever-decreasing reserves of cultivable land, mean that for many developing countries it is at least as likely that migration will accelerate as that it will fall off. Existing trends indicate that most of the large cities will double in size within 15 years and many in less than 10 years.[1]

An even faster rate of growth is to be expected in urban transport requirements. Average trip distances lengthen as a result of increased size of urban areas combined with concentration of activities. Commuting-to-work trips, which customarily represent nearly half of all trips and a much higher proportion at peak hours, are particularly affected. Where walking previously sufficed, cycles and motorized or rail transport are increasingly needed simply to reach work. Diversification of amenities reinforces the tendency.[2]

Impact of Higher Incomes

Growth in incomes will further accentuate the growth in demand for urban transport facilities. The highly skewed income structure of most cities in developing countries means that a general rise in in-

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[1] *Improvements to national transport and communications systems, by reducing the relative importance of small and intermediate towns as marketing, stock-holding and distribution centers, may tend to reinforce the predominance of major metropolitan areas.*

[2] *Average lengths of motorized trips are strongly related to physical size of the city. The extent of physical expansion with growth in population depends in turn on how population densities vary. Initially, densities may rise, thus restraining the increase in average trip length—though not the growing complexity of living, and hence number of trips desired. Higher densities mean that more pairs of origins and destinations are brought within walking distance. At a later stage of higher incomes and lower population growth, densities usually decrease, particularly where expansion in transport capacity allows higher speeds that ease longer commuting distances.*

comes produces a more than proportional increase in the number of families which are able to afford a car. This tendency is reinforced by the worldwide trend for automobiles to absorb a larger share of personal expenditures at given income levels, reflecting the strong benefits which car owners derive and the increasing familiarity with motorized transport from one generation to the next. Hence, the extremely rapid growth in private automobiles already noted must be expected to continue. Recent projections indicate that the car population of the developing world will jump from about 17 million in 1970 to 117 million by the turn of the century.[3]

Unlike the more developed countries, however, the main growth in demand for urban transport in the poorer of the developing countries for many years will be at the frontier between the bus and walking or cycling rather than between the bus and the automobile. Though this has so far received much less attention, the number of buses is likely to increase greatly.

As private automobiles take roughly nine times more road space per passenger than buses, and bus travel will be replacing walking, demand for road space can be expected to rise very sharply in the developing countries with income growth. Savings and municipal revenues that can be devoted to urban transport will also rise with incomes, but not with such rapidity.

A fast growth of urban commercial traffic must also be expected to result from rising income levels and relatively rapid expansion of modern manufacturing and retailing sectors. If the experience of developed countries is followed, as seems likely, the number of commercial vehicles will rise more slowly than the ton-miles, due mainly to use of larger vehicles as trade expands.[4]

The Rising Cost of Central Area Roads

The prospects of rapidly increasing pressures of demand for urban transport in developing countries are coupled with prospects of rapidly rising costs of supply. Particularly important are costs of roads, since roads are usually by far the most important component of investment in urban transport infrastructure. Whereas the network of low volume neighborhood roads can be expanded at relatively low

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[3]*Gerald Leach,* The Motor Car and Natural Resources, *Organization for Economic Co-operation and Development (OECD), 1973. Estimates are for "rest of the world" covering all countries except those of OECD.*

[4]*The OECD projections referred to above show the commercial vehicle population (bus and goods) of the "rest of the world" rising from 13.7 million in 1970 to 18.5 million in 1985 but the rate of increase then tailing off rapidly to give a total of 21 million in use in the year 2000.*

cost as the cities grow,[5] the costs of expanding road capacity in central congested areas rise sharply with urban growth. Costs of centrally situated land, whether reckoned in financial or economic terms, increase rapidly with city expansion as also do construction costs, including property acquisition, demolition and dislocation costs.

Physical limitations on land availability as well as the rise in costs of enlarging existing roads may eventually warrant construction of limited access highways. Offsetting much larger costs, which may exceed $2 million per lane-mile, the higher speeds of uninterrupted and more uniform traffic result in much greater effective capacity. Even so, the direct construction costs for a stretch of urban expressway, say five miles long, if attributed to the peak-hour traffic for which they are primarily incurred, are likely to exceed $2.50 per vehicle per working day at a 10% rate for amortization and maintenance. Additional social costs in the form of breakup of neighborhoods are, moreover, much greater than for expansion of existing arterials.

One important consequence of the sharp increases in costs of constructing additional road capacity in central areas is that much higher benefits are required to justify the construction. What this means in practice is that, progressively, a higher degree of congestion has to be tolerated before more road construction to alleviate the situation can be justified. Since a large part of the benefits to be secured are time savings which are, in general, valued at less than in developed countries, more hours of time need to be saved to balance the expense; a higher level of congestion than in developed countries is accordingly warranted.[6] With so many urgent needs to be met, uncongested streets in city centers at peak hours would be a sign of serious imbalance in the use of scarce resources.

Effects of Congestion on Costs of Road Vehicle Operation

With greater congestion, higher operating costs of all types of road vehicles are to be expected as well as increased losses of personal time, discomfort and pollution. The impact of congestion varies, however, between different forms of urban transport. Buses are particularly adversely affected, lessening their relative attraction as compared with private automobiles. The deteriorating conditions of road transport may also cause switches to urban rail and other forms of nonroad transport.

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[5] *They may indeed be subject to increasing returns in terms of the volume of traffic they can and do accommodate. Annex 5 provides a further analysis.*

[6] *Actual congestion levels in developed countries, as in developing countries, are, however, generally well above those which would be warranted with rational road pricing.*

The vulnerability of buses to congestion is in part due to the composition of their costs. More than three-quarters of the total costs per bus-mile—now typically somewhat over 50 cents—are accounted for by operating costs in which labor costs for driving, ticket collection, maintenance and administration form the main part. The delays of congestion cause both labor and fuel costs to rise sharply. Moreover, congestion is particularly severe on the main bus routes where most bus passengers are to be found. Congestion delays to buses are, in any case, greater than for automobiles; to the increased difficulties of pulling into and out of bus stops is added "bunching" of buses which greatly increases average time at stops. Capital costs also rise since with lower speeds and "bunching" more buses are required to move the peak-hour passenger volume. Costs per passenger-mile, now typically a little over 2 cents, may, however, rise proportionately less than costs per bus-mile. During peak periods, the greater number of passengers carried per bus may offset the lower number of bus trips. Passengers suffer from congestion primarily through longer times spent in waiting, boarding and traveling and considerably greater discomfort.

Travel by private automobile is, of course, much more expensive. Typical costs now probably fall in the range of 15 to 20 cents per automobile-mile in most cities of developing countries, or an average of around 9 cents per passenger-mile. This is about five times the cost of bus travel per passenger, or three times if cars are loaded near to capacity, as, for example, when car pools are formed. Differentials are still larger if allowance is made for parking expenses.

Once a car is owned, however, the difference between the running cost of using the car and the bus fare is generally much too small to attract car users to the bus. Unlike buses, capital costs of automobiles represent a high proportion of total costs largely because automobiles run for fewer miles and the driver is not paid. The running costs which vary with car use generally do not exceed 9 cents a mile giving an average of about 4 cents a passenger-mile. This is not so much above the level of bus costs and fares as to offset the automobile's great advantages of convenience and speed. Moreover, "perceived" automobile costs are below actual running costs since some costs which vary with mileage, such as part of depreciation, are usually underestimated by owners.

In the "stop and go" conditions of congestion the advantages of automobiles are greater in comparison with buses. Fuel costs rise, but not by more than one or two cents a passenger-mile; total costs are proportionately little affected. Passengers lose less time than in the case of buses, partly due to the automobile's ability to use less congested routes, and comfort is relatively little affected. The dangers of encouraging the use of private automobiles at uneconomic rates are thus increased. In the cities of developing countries, where public transport typically accounts for a high proportion of trips other than walking, a shift of even a few percent of passengers to private automobiles can cause a dramatic intensification of congestion and further increase bus and commercial traffic operating costs.

Commercial vehicles, like buses, are severely affected by congestion. Labor costs represent a large part of operating costs and congestion delays increase this element and at the same time necessitate a larger fleet of vehicles to move the same quantity of goods. "Stop-go" conditions raise fuel costs substantially and also depreciation. Increased uncertainty of delivery times can also have important repercussions on production and selling costs. Moreover, congestion is often particularly acute around such areas as docks and markets which are primary destinations of commercial traffic.

The Possibilities of Mass Transit

In this dilemma of higher track and operating expenses for road vehicles, attention is inevitably directed toward the separation of different types of traffic, and particularly public transport, so as to reduce interferences between vehicles of differing characteristics and ensure essential services. The potential of reserved lanes and traffic engineering for partial segregation of public transport is considered in the following chapter. It may be noted here that this potential is important but, beyond a certain point, is subject to many limitations. More radical is the provision of mass transit on separated rights-of-way, either above or below ground, so that public transport can operate unimpeded while releasing road capacity for other traffic.

The basic difficulties with mass transit solutions are two. First, the minimum capacity of any separate right-of-way established for public transport is very large while costs of construction are inevitably high. Construction costs of metros, for instance, typically average in excess of $10 million a lane-mile and are much higher than this where tunneling conditions are difficult. Capital costs for surface tracks are less, but costs per passenger-mile are still likely to be prohibitive unless traffic volumes are very large, including substantial volumes at off-peak periods to help defray the costs of rolling stock and staff needed for the peaks.

The second difficulty is that separated rights-of-way, particularly for rail traffic, are constrained in the sense that once a route has been developed, it is fixed in location and limited as to type of traffic. In combination with the cost/capacity constraint, several consequences follow. Feeder services are required to extend the segregated track service into areas of low traffic density. Further, the need for interchanges, and the necessary delays caused by starting, stopping, and taking on passengers mean that average speeds of travel by mass transit do not in practice rise much above 20 miles an hour, at least where stops are frequent.

The space specificity of urban railways and metros can create a serious danger of accentuating the traffic problems that they are designed to reduce. Employment location around central area stations is at a premium since transfers to other modes are thereby avoided while maximum benefit is derived from the speed and other conveniences of the railway or metro. Workers traveling by other modes, however, are then also attracted to this small highly concentrated area by the increased employment opportunities. Road congestion may eventually increase rather than decrease as a result of providing rail or metro facilities.[7]

These characteristics are considered in greater detail in Annex 5. As a reflection of the inherent constraints, however, it may be noted that there are only 25 major metro systems currently in operation, though nearly half of them have been added in the last two decades. Of these, all but five are in cities with populations above 2 million. All but six have an annual ridership in excess of 100 million rising, in the case of Moscow, to over 1,500 million. The only two in this range in the developing countries are those of Buenos Aires and Mexico City, though these can be expected shortly to be joined by Sao Paulo and Seoul. The fares charged on the more recent systems vary from a minimum of about 12 cents for a short journey in the case of Mexico City to 30 cents in the case of Toronto. Fare levels such as these are clearly beyond the incomes of the poorer classes of population in most of the larger Asian and African cities.

To escape from the constraints of urban rail and metro systems and yet reap the advantages of separated rights-of-way, segregated busways may provide an attractive alternative for coping with high volumes of passengers. Practical implementations of busways have so far been few. They appear, nevertheless, to offer considerable potential, particularly for the developing countries where volumes of bus passengers in relation to urban populations should be much higher than in developed countries. Ordinary buses can be used, which can

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[7] *Some of these difficulties may be avoided by the use of streetcars and other light railways which have greater flexibility and certain other advantages; but these modes are particularly prone to interference by other traffic at intersections and consequently lose much of the advantage of segregation.*

enter and leave the busway to provide feeder services. Moreover, a separate right-of-way may not be needed for anything like the whole length of the route, nor for the entire day, nor to be so exclusive as for rail. Other public vehicles such as minibuses and taxis, or essential service vehicles such as ambulances, can be permitted to use the same track where excess capacity above bus use is available, as it normally will be. As to costs, the available evidence indicates that high capacity busways may often be more economical than new railways for developing countries. Recent studies in several cities indicate costs of track of the order of $1 million to $2 million a lane-mile as typical, comparing favorably with new rail track, while costs per passenger of vehicles and signaling are also lower.

Busways tend to require considerably more surface area than metros and ventilation to evacuate exhaust fumes may greatly increase the cost of any deep tunneling involved. These factors may preclude bringing busways into the heart of the business district. It may also prove administratively difficult to exclude other traffic in conditions of some developing country cities.

To summarize, if events are allowed to take their course, the prospects for urban transport in developing countries are of seriously deteriorating conditions. Shortage of resources, rapidly increasing demand and rising road costs threaten to lead to more congestion and a strong upward trend in the general level of urban transport costs. Because of high infrastructure costs, metros and other forms of mass transit on separated rights-of-way can at best only contribute to a solution. Higher transport costs will be reflected in higher costs of production, or reduce the gains from increasing productivity. Personal standards of living also stand to be adversely affected by delays, reduced comfort of travel and deterioration of physical and social environment.

Chapter 3: RATIONALIZING THE USE OF TRANSPORT FACILITIES

The prospect of sharply deteriorating conditions, if present trends are allowed to continue unchecked, makes urgent a reconsideration of policies affecting urban transport. Three main directions for improvements are evident. They are: first, securing more rational use of transport facilities and particularly road space; second, improving the efficiency of transport undertakings and their coordination; and third, reducing transport requirements through improvements in the physical structure of urban development.

In each of these fields, practical opportunities for effective action are often larger in developing than in developed countries. Levels of motorization are still relatively low; hence, a wider choice of alternatives exists for future patterns of urban transport. Efficiency of urban transport operations is often very poor; the scope for improvements is correspondingly large. As half of the city area of 10 years hence has not yet been built and changes in land use are extremely rapid, the options of future physical form are much wider despite the shortage of resources.

This chapter examines the potential for policy changes to secure more rational use of transport facilities. In all countries, restraints are placed, to a greater or lesser degree, on the rights of individuals to use road space—particularly when such use impinges on the extent to which others can use the road, as happens in conditions of congestion. Current conditions, nevertheless, indicate an urgent need to examine more closely the justification and effects of differing types of restraints. Of these, pricing measures for charging the economic costs involved merit, and are given, first consideration. As pricing measures appear unlikely to be sufficient by themselves to ensure essential transport services, it is also necessary to consider various measures of physical restraint that can help produce a better balance. If basic commuting services are to function adequately, specific road priorities must be accorded to public transport, cyclists and pedestrians to reduce interference from other traffic.

Pricing Measures

Private automobiles require a disproportionate amount of road space per passenger as compared with other modes of passenger transport. As a result, in congested areas private automobiles inflict heavy costs on other road users as well as nonroad users. These costs are not reflected in higher charges for use of congested roads by automobiles. In such conditions where vehicle owners do not bear the full costs of their use, the market mechanism does not work to produce efficiency. Each individual using the road may be making the correct decision so far as he is concerned but not so far as all road users or the community is concerned.

Congestion pricing: There is by now broad agreement on the rationale for estimating appropriate pricing for use of congested roads. Where traffic volume is such in relation to capacity that each vehicle interferes significantly with the functioning of others, economic efficiency would be gained by making each vehicle on the road bear the costs that its addition on the road imposes on others. All trips the value of which to the persons making them is less than the value of delays and other operating costs caused to others would thereby be eliminated. To compensate for other inconveniences caused to nonroad users such as pollution, noise, and environmental degradation, an additional element should be included in the congestion charge. Any lower level of pricing results in too many vehicles using the high cost facilities with consequent excessive congestion and loss of efficiency. That taxes on private vehicles in total often exceed the current level of public road expenditures is not, in these circumstances, relevant.

The precise formulation of appropriate levels of congestion charges raises difficulties.[1] But these are generally not of importance in practice since existing charges are so far below the optimum for economic efficiency that the choice of any of the alternative criteria put forward would result in a very marked improvement. Various estimates indicate that vehicles should typically be charged at least a dollar a day for the use of central area roads at peak hours; and most estimates are for several times this amount.

No country has yet instituted a satisfactory system of charging for use of congested roads, although various schemes are now under consideration both in developed and developing countries. Political and technical difficulties are involved, with the former probably the more important. Decision makers are under strong pressure from car owners who are naturally averse to higher charges and discount possible benefits. There is also a more general opposition to rationing road space provided for public use by the power of the purse. In pre-

[1] *The difficulties include estimating in advance how much traffic levels will fall with increased charges. This is needed for determining the appropriate charges. An alternative is sometimes suggested of levying charges in accordance with the cost per vehicle of expanding capacity in the area concerned, or of expanding capacity elsewhere to give relief to that area.*

vailing conditions of income distribution, the rich could readily absorb charges that would weigh heavily on the politically powerful marginal car owners many of whom will have invested in automobiles and based their residence location on the use of the automobile for commuting. The benefits from congestion pricing of cheaper and faster travel for those who do not use private cars are rarely given adequate consideration.

It has proved technically difficult to devise systems of congestion charging that are efficient in incidence, feasible in terms of implementation and without important adverse side effects. Annex 6 reviews the merits of various forms of vehicle and road use charging. A package of measures including a system of daily charges for the use of roads in central areas at peak hours in combination with economic parking charges may be the most appropriate.

The case for starting immediately with a program for progressively raising charges for the use of congested roads is strong; delay increases the political difficulties since the number of private automobile owners is growing rapidly. Both the opportunity for introducing congestion charging at an early stage of motorization and the overall shortage of resources make such charging far more desirable in the developing countries than even in the developed. In principle, buses should also be subject to congestion charging. However, at least until the private automobile is rationally charged, exempting buses from congestion charges appears justified; the charge per passenger would in any case be quite small compared with the private automobile.

Where congestion charges cannot for any reason be introduced, higher general taxes on ownership of automobiles and/or quotas are likely to provide the only effective alternative pricing method for ensuring adequate road space for essential purposes. With automobile ownership in developing countries so heavily concentrated on the urban centers and use in peak hours, the losses involved from unnecessarily restricting automobile use of uncongested roads may be more than offset by the advantages of restraining use on congested roads. Overall fiscal and foreign exchange considerations, too, often favor use of general ownership taxes. From the point of view of rational use of roads, however, this is a distinctly "second-best" solution. Off-peak use is in practice likely to be more restrained than the relatively essential peak use for work trips. At high tax rates, the impact on use of private automobiles for business becomes an increasingly important drawback. If commercial vehicles are excluded from the taxes, they tend to be used increasingly for passenger trips.

Just how much effect congestion charges or more general taxes will have in reducing peak-hour congestion cannot be readily determined in advance. There is no real experience and little accurate knowledge of the latent demand, and too much depends on the precise method of charging and efficiency of implementation. Hence, effects need to be monitored and charging policies adapted accordingly.

It would, nevertheless, be unwise to anticipate any spectacular reduction in levels of congestion as a result of such charges, as it may be politically feasible to introduce at any one time. Such is the extent of latent demand and the underlying rate of increase of requirements for urban transport in most cities of developing countries that the impact on the total flow of vehicles may not be very obvious. Demand is likely to catch up quickly with road space released by better pricing.[2]

To deduce that increased charges are irrelevant would, however, be wrong. The main benefits lie in changes in traffic composition, in reductions in underlying demand and in impacts on urban form. Buses and other public transport vehicles will gain in speed and costs relative to private vehicles as a result of congestion charges; a larger total volume of passengers will be transported for any given degree of congestion. Reductions in private vehicle peak-hour volume will lessen pressure for additional transport infrastructure. Financial resources will be mobilized through the charges. In the longer run, the largest beneficial results may well be the influence on location, particularly in reducing pressures to urban sprawl. This aspect is discussed in greater detail in the chapter, "Transport and Urban Form."

Congestion charges also place the authorities in a much better position to assess what additional transport facilities are economically justified. The apparent advantages of additional transport capacity are exaggerated by unnecessary congestion on existing roads—but by an amount which it is difficult to analyze in the absence of charges. Moreover, the subsidization of road users limits the fares that can be charged for rail transport, contributing to the lack of profitability of rail systems and deterring investment in them. These points are considered further in the discussion of methodology in Annex 7.

Fare differentiation: Higher public transport charges at peak hours are also often advocated as a method of curbing travel at peak hours when costs are highest. Operating costs per public transport vehicle

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[2]*Several studies have indicated possibilities of congestion and parking charges reducing traffic flows by about one-fifth. But automobile ownership is frequently increasing at rates of 10% to 20% a year so that, if incomes continue to grow, the trend will only temporarily be halted. Moreover, in some cities, official and company cars are a high proportion of total private vehicles and, at least in the short run, their use is likely to be inelastic to tax increases or congestion charges. It is indicative that increases in gasoline prices of 50% seem to have produced reductions in gasoline use of less than 10% in many countries and have had probably even less effect on peak-hour automobile use.*

are indeed substantially higher at peak hours due to delays. But as these costs are shared by the many more passengers squeezed into the vehicles at peak hours, costs per passenger may move either way. Put another way, peak-hour pricing does in fact occur through the much lower levels of comfort and speed offered for the same fare—thus effectively dissuading those passengers who can conveniently travel at another time. Remaining passenger travel demand for transport at peak hours is likely to be relatively inelastic, being confined largely to essential travel such as journeys to work. The major effect of raising prices will then simply be to force the poorest passengers to walk.[3]

To maximize the use of fixed investment in urban transport does, on the contrary, require consideration of reduced fares during slack periods providing that the fares cover the marginal costs of vehicle operation. The lower fare will not attract many travelers from peak periods due to the essential nature of most peak-hour traffic. But they will greatly increase travel opportunities for many citizens who cannot afford the regular fares. Overall, off-peak demand for public transport should be much more elastic to fare reductions than in developed countries, where price is a lesser limitation and the automobile is much more available.[4]

Economic efficiency also points to varying fares with the distance traveled. Flat rate fares subsidize passengers traveling longer distances at the expense of those traveling shorter distances, thus encouraging longer trips and urban spread. If routes are short, however, the delays caused and other costs of fare differentiation may outweigh the gains.

Measures of Physical Control

For reasons indicated earlier, pricing measures generally cannot be expected to be introduced to the full extent indicated by economic efficiency considerations and, in any case, substantial congestion needs to be tolerated if benefits are to justify expensive new transport capacity. The highly skewed income distributions favoring private automobile traffic, and the large uncosted "diseconomies" adversely affecting the physical and social environment, translate into a need for additional measures to ensure the transport functions most vital to the city's efficiency. Such additional measures may be of an administrative nature including variation in hours of work, or general physi-

[3] *If, however, fares are too low to cover costs, so that numbers of buses and service are curtailed due to lack of finance, a general increase in fares may nevertheless be indicated.*

[4] *See also the discussion of subsidies in the following chapter.*

cal restraints designed to allocate road space more efficiently, or traffic engineering to improve traffic flows and give priority to public transport and other essential traffic.

Staggered work hours: Staggering hours of travel, lengthening the peak period but reducing the intensity of congestion, occurs to some extent naturally as congestion increases. A more efficient spreading of the travel loads is also possible through the phasing of hours of work, particularly of government offices, shops and schools.[5] The scope for such improvement depends on the extent and intensity of the peak period and may not be large where peak periods are already long. The inconveniences and costs involved in differentiated working hours must be carefully weighed against the advantages of reducing the costs of additional peak-hour transport capacity.

Regulations limiting hours for deliveries of goods in congested areas may also be justified, particularly as parking charges have much less effect on commercial than on private automobile traffic. Such regulations can also be extended on environmental grounds to limit noise and nuisance at night. While regulations on commercial traffic are in extensive use, it is by no means apparent that the economic costs have been sufficiently weighed against alternative restraints on other traffic.

General physical restraints: Because of the complexity of special licenses for the use of congested roads, general physical restraints or prohibitions of private vehicles at peak times in specified areas are being increasingly resorted to.[6] The practical difficulty in developing countries of collecting charges for street parking may itself justify complete prohibition of parking in congested areas. Like special licenses and parking charges, complete parking prohibitions disadvantage vehicle owners who live and work in the controlled areas. Vehicles driving through the area or vehicles which are provided with parking on private premises are, on the contrary, favored. In this connection, some municipalities are now setting maximum limits on new parking space provided in new office buildings, an approach that deserves more general consideration. Diversion of through traffic by physical obstructions and signaling to roads outside the main congested area also merit consideration as also the use of signals to dissuade traffic by increasing the time required to reach destinations in districts particularly vulnerable to congestion.

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[5] *In Singapore, the spacing of school and commuter travel allows school buses to be used also for carrying commuters to and from work.*

[6] *Quota systems on imports can also be regarded as an extreme form of physical prohibition. Quota systems are considered in Annex 6.*

The largest restraint to traffic in most big cities, however, remains that of congestion itself. Given the extent of demand, congestion appears likely to retain this role in the foreseeable future. The control exercised by congestion on the pattern of urban growth is automatic. Difficult decision making is minimized—but at the cost of an uneconomic, time-consuming system of rationing. As congestion does not reduce latent demand, political pressures for large, and often uneconomic, highway expenditures remain. Congestion can, however, be more or less inefficient in its impact. If signaling and other physical restraints are used purposely to create bottlenecks at places where the queuing that results has little further impact, speeds and capacity of roads beyond the bottlenecks may be increased and the overall level of delays diminished.[7]

General physical restraints have certain inherent disadvantages. Traffic is impeded at times when this serves no purpose. It is difficult to ensure that congestion is not just transferred elsewhere. Inevitably, too, the incidence of physical restraints varies from one traveler to another, often in ways which are inequitable or politically unacceptable. Business contacts and, more generally, trips traversing the sector may be seriously disrupted even when reasonable transport alternatives do not exist.

Traffic engineering and priorities: A more positive approach to promoting efficient use of transport facilities is by traffic engineering to reduce the obstruction that different flows of traffic cause to each other, particularly at intersections.[8] Effective road capacity can, in some cases, be increased by 50% or more by installation of coordinated signal control, by intersection redesign or elimination, and by other control measures. Similar opportunities exist in the upgrading of urban rail systems. It is surprising how often such possibilities are neglected in favor of much more costly road expansion.

Traffic engineering, however, needs to be associated much more closely than in the past with ensuring the adequacy of basic transport services. Road capacity in terms of passengers rather than vehicles could be increased even more if improvement in public rather than private transport became the focus of attention. Specific measures to disentangle buses from traffic congestion such as priorities for buses

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[7] *Various schemes have been developed in European and American cities to meter traffic on to congested roads so as to prevent conditions of hypercongestion from emerging and to maximize traffic flows. It is often difficult, however, to find locations for restricting flows so that the benefits are not offset by the resulting back-ups.*

[8] *Intersections generally have half or less of the combined capacity of the intersecting roads. Prohibition of street parking without measures to increase intersection capacity may, therefore, have limited advantages for traffic flows. One-way street solutions need to be treated with caution as the increased distance traveled may more than offset the increase in speed achieved.*

at intersections, reserved bus lanes and limited access streets are of particular importance. Buses can also be allowed to traverse physical barriers arranged to prevent through traffic of other vehicles. Street arrangements permitting quick turn-round of buses and reduced boarding times can also be effective. It may be possible, by such means, to offset a significant part of the inherent time disadvantages of travel by bus as compared with travel by private automobile.[9] Unfortunately, priorities for buses in congested areas often raise severe problems of traffic management, and may not be easy to implement without undue inconvenience to others.[10] This inconvenience can be somewhat lessened by limiting priorities to peak periods of congestion.

The requirements of pedestrians and cyclists clearly deserve far greater attention than they have received. In the poorer cities of the developing countries, large sections of the population will continue to be unable to afford public transport. Curtailment of sidewalks to increase road vehicle capacity should only be undertaken after much more careful evaluation than is customary. Indeed, consideration needs to be given to closing of some streets to vehicular traffic at peak periods where this will increase total person flows. Shopping precincts such as are being increasingly adopted in many European cities in recent years, and which already exist in the *suks* and bazaars of many cities of developing countries, have also many advantages.[11]

Separate tracks for cycles and motor-assisted cycles offer considerable potential both for the cyclists and to other traffic. As noted in Annex 5, cycling has great advantages as a cheap and relatively fast form of transport, but in mixed traffic these advantages are greatly reduced and interference with other traffic grows. The simplicity of cycle tracks does not reflect their importance, though it often leads to neglect of their potential. Failure to provide adequately for pedestrians and cyclists will on the one hand unnecessarily increase the demand for more expensive motorized transport and, on the other, greatly reduce accessibility for those who cannot afford motorized

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[9] *Reduction of congestion for buses increases reliability and reduces the time that has to be allowed for failure of the bus to arrive or for it to be full. Bus stops more convenient to bus passengers may also be warranted even if some additional delay is caused to private vehicles.*

[10] *Several experiments are now in progress, particularly in the United Kingdom, to provide unobstructed but not necessarily exclusive rights-of-way for public transit vehicles by priority of entry onto roads on which the total flow is restricted to free-flow conditions by monitoring. Reserved lanes for buses and taxis in the contraflow direction on one way streets or approach roads to central areas may also help.*

[11] *Initial opposition by shop owners to these schemes has generally been replaced by enthusiasm in the longer run. However, particularly in large cities, requirements for alternative routes for vehicle through traffic generally limit the schemes to fairly small areas.*

transport. This is most clearly seen in cases such as Jakarta where road widening in central districts has been accompanied by failure to provide adequate pedestrian ways and the banning of "bekjas"—a cheap but slow-moving cycle-powered taxi. The mobility of the poor has been greatly reduced in consequence. Provision of separate track for cycles and other slow-moving traffic, rather than their banning for the convenience of motorists, is rarely in practice given the serious consideration it deserves.

Chapter 4: PROMOTING EFFICIENCY AND COORDINATION AMONG AGENCIES

The measures discussed above to promote a more rational use of transport facilities by economic pricing, physical restraints, and priorities for essential services require supporting action to strengthen the agencies involved in supplying transport services. Purposeful action over considerable periods is involved in achieving efficiency of individual transport undertakings, in ensuring a more appropriate balance between different forms of public transport, and in developing methods of coordination that result in an economical integrated transport system in which the different elements complement each other.

Public Transport Operations

Standards of management and efficiency of publicly run transport undertakings in developing countries vary greatly but are in general poor. Lack of finance and outdated regulations are contributory causes, but so also are more general problems of neglect. Urban railways in particular often suffer from low management attraction due to reputations of being the most problem-ridden and loss-making sections of national railway systems. Such aspects point to the need for a concerted attack on several fronts to reverse current neglect and improve efficiency.

In municipal bus and urban rail companies possibilities for improved efficiency are very evident. Variations in standards of service, costs, and operating ratios are too great to be justified solely by the inevitably differing conditions from city to city. Wide variations in staffing ratios—employees per bus may vary from around 3 to over 10—and maintenance and repair schedules provide further evidence. Technical assistance can be of great value here in spotlighting deficiencies, and, if given sufficient political backing, in promoting remedies. Private bus and intermediate personal transport undertakings generally appear more efficiently run.

In this context, attention urgently needs to be focused on the financial situation of public transport agencies. Cheapness of public transport services is of primary concern in most cities of the developing world. The emphasis must, however, be on reducing costs and not simply on keeping down fares. For the majority of the urban inhabitants, speed and comfort are certainly of low importance compared with fares, and lower levels of service than in richer countries are hence appropriate. But reluctance to permit fare increases when costs have risen results, in all too many cases, in the decapitalization of the companies even with extreme overcrowding of serviceable vehicles. Neglect of finance for municipal bus and urban rail undertakings by national and international institutions has clearly not helped.

The consequent lack of resources is a major cause of continued use of obsolete vehicles, very high rates of breakdown, of workshops concentrated on emergency repairs to the exclusion of routine maintenance, and of vehicles standing idle for want of spare parts. In the case of bus companies, repair facilities have not been expanded or reequipped in line with the increase in bus fleets; they often become poorly located as the cities continue to expand.

These conditions greatly accentuate problems of raising fares to adequate levels. Opposition to fare increases must in any case be expected to be politically more explosive in developing than in developed countries, such is their importance to the urban poor. But deteriorating services inevitably further strengthen the opposition. Improvements of efficiency and fare increases should hence be related where possible; this may require "bridging" finance.

By no means all the troubles, however, are attributable to inadequate fares and shortage of external finance. The fares which are inadequate for public undertakings are often profitable for independent bus companies with lower overheads. Overstaffing is frequently a major cause of poor performance of municipal bus and urban rail companies; strong political backing is required for its resolution. General management weaknesses are an important contributing factor and to resolve them requires official action as also in the case of inadequacies of the regulatory authorities discussed later in this chapter.

Subsidies for Public Transport

It is in the wider context of operating efficiency rather than of financial difficulties that subsidization of public transport deserves primarily to be considered. First, however, it may be noted that where, as is prevalent in developing countries, public transport undertakings are required to provide some services free or at fares below costs, for example to school children or police, financial transfers from public funds to cover the extra costs borne by the undertaking are generally justified. The requirement to carry such passengers below cost may itself be questioned, however, as it is by no means evidently the best way to promote welfare even when instituted on social grounds.

More difficult to judge are cases where the costs of carrying additional passengers are less than average operating costs, so that a loss is or would be incurred at fares which meet "efficiency" tests of marginal pricing. Such cases may occur, for instance, when surplus track capacity exists in mass transit systems. Fares higher than the efficiency price, such as fares based on average costs, may in such circumstances increase net revenues but cause a more than corresponding loss in consumer benefits—from less use of the service and from the higher charges on those who do not use the service.[1]

A case for subsidies to public transport can also be made where absence of congestion charges strongly favors the private car. A subsidy reducing bus fares may, in these circumstances, result in a closer approximation to relative real costs and a better allocation of resources between modes—and even, in certain circumstances, to an improved allocation between urban transport and other sectors. Similar arguments can be made in favor of subsidizing rail fares to compensate for implicit subsidies to underpriced users of congested roads, thereby promoting a more efficient division between road and rail.

Although these arguments for subsidies have considerable weight in specific circumstances, it is always important to ask what will be achieved by the subsidy in the precise form proposed, what the alternatives and the practical drawbacks are. A general subsidy covering a deficit creates the risk of producing financial irresponsibility rather than promoting efficient operation. Hence, any subsidy should be tied to the achievement of precise objectives in terms of development of new services, frequency and reliability of services, possible lowering of fares, or other specific improvements.

In assessing what the subsidy will achieve, long-term as well as short-term effects must be considered. Provision of transport below cost, whether public or private, increases transport use and exerts additional pressures on resources. People will choose more outlying residences. Employment eventually tends to become more dispersed. Pressures to build more and higher-standard roads are accentuated. The addition of urban transport riders to the ranks of subsidized travelers accentuates tendencies to urban sprawl and may, as suggested later, have serious adverse impacts on urban patterns.

Nevertheless, failure to provide financial support to public transport when no feasible alternative exists in the short run for maintaining or improving the public transport service certainly *can* prove more

[1] *Account should also be taken of the congestion caused by transfers of public transport passengers to private automobiles due to fares above marginal costs. More congestion, in turn, leads to greater expenditure on roads and a reduction in quality of bus service. This effect, however, appears unlikely to be of great importance except in the richer developing countries.*

costly than a well designed subsidy from both economic and social viewpoints. This is particularly true if subsidies are tied to expansion of the service rather than designed primarily to help existing riders. Even so, a careful assessment of the local conditions is needed before a case for the subsidy can be substantiated. Who gets the subsidy and who pays for it are, in this respect, of particular importance. The case is greatly weakened if the subsidy would effectively come from general taxes falling particularly heavily on the poor, many of whom cannot afford public transport anyway. In practice, moreover, there may well be other public expenditures, for example on water supply or health, that the poor would prefer.

Development of Intermediate Personal Transport Services

The wide income range between automobile owners and the urban poor of developing countries presents a need for a correspondingly wide spectrum of intermediate transport services. A bus service sufficiently cheap to be affordable by the large poorer groups of the community involves standards of comfort and service very much below those of the private automobile. Accordingly, if potential automobile users are to have a reasonably attractive alternative, forms of personal transport giving significantly better service than the normal bus but at costs appreciably below those of the automobile are required. At the other end of the spectrum, public transport using older vehicles with more standing room to provide even cheaper, if slower, service than the regular bus may be advantageous for large groups of poor citizens. Personal transport vehicles smaller than a regular bus can also fill an important need in districts where traffic is too low or roads are too difficult for regular bus services.

In the development of such intermediate personal transport systems as minibuses with ensured seating, shared taxis and jitneys, the flexibility of small private enterprises can play a significant role. But this potential is often reduced by regulations designed largely to protect bus systems from competition. Within the context of bus priorities and management improvement discussed earlier, there seems often no valid reason to deter competing intermediate personal transport services. On the contrary, the case is generally strong for giving them some of the priorities accorded to buses, such as use of reserved lanes in congested areas, where this does not interfere with the bus service. Similar priorities may, under favorable circumstances, also be used to encourage private car pools. However, individual city conditions vary so considerably that the impact of additional types of transport services and priorities on existing public transport systems needs to be assessed on a case by case basis.

Problems of Coordination and Regulation

It is perhaps not surprising, since institutions tend to adapt slowly, that the exceptional rates of urban expansion of the last two or three decades have greatly increased the evidence of failures to develop complementarity among urban transport services. Intercity roads are generally constructed with little attention to balancing capacity in the urban road distribution system; intercity bus and freight lines suffer also from inadequate terminals and linkages with corresponding urban facilities. The wide variety of regulatory bodies involved greatly increases the difficulties of securing improvements. With urban transport systems so fragmented, it is often nobody's specific responsibility to study the most advantageous interconnections and complementary services, or to iron out the physical difficulties and those of reallocating routes.

Perhaps less obvious, yet no less serious, are the failures of coordination between transport operators and the public works department or other road building agencies. Bus routes, for example, are often not supplied where most needed, as in outlying squatter areas, due in part to inadequate roads. Traffic engineering usually gives scant attention to the special needs of public transport and commercial vehicles.

No less important is the scope for making the various measures for urban transport improvement self-reinforcing by coordinated timing. Appropriate charging of congested roads will, for example, be more readily acceptable if accompanied by promotion of intermediate personal transport. Bus priorities are unlikely to be fully effective unless accompanied by other measures of traffic engineering and management. Fare increases can be timed to coincide with improvements in service.

Institutional, political and legal frameworks vary too greatly to permit valid generalizations on the most appropriate institutional forms for securing the requisite coordination. Urban transport authorities covering all branches of the transport network are by no means necessarily the most effective answer. The dangers of slow-moving large bureaucracies involved in the actual operation of transport undertakings are evident. Critical examination of basic weaknesses in the transport system is apt to become more difficult if conducted by the entity responsible for operations. A single agency for operating all bus and urban rail routes may provide great advantages in terms of resolving problems of complementarity and raising capital. It may also succumb to the temptation of subsidizing unprofitable routes by profitable ones to the detriment of the expansion of the more efficient services. Restriction of more efficiently run private bus companies may then appear necessary to preserve financial viability.

Dangers in overregulation of urban transport services by regulatory agencies are indeed evident. The development of new routes or adaptation of old ones is in practice often hampered by out-of-date restrictions, a matter of particular concern in conditions of very rapid growth of cities and change in land use patterns. Intermediate personal transport services tend to suffer particularly from inflexible regulations. Here, as in many other aspects of urban transport planning and regulation, consumer participation at some stage in the decision-making process and the questioning of consumer preferences have obvious importance.

Solutions to problems of coordination which avoid the dangers of overcentralization and overregulation will often be found to include the establishment of a small analytical and policy unit close to the center of municipal decision making. The major issues are not merely technical; they generally involve evaluation of gains and losses to different groups of citizens and the performance of managements of the different agencies. Such a unit should ensure adequate contacts between the agencies and also provide a link with the wider aspects of urban planning discussed below. The inevitable limitations of such a unit need, however, to be borne in mind in allocating responsibilities, if it is not itself to become a bottleneck. Clearly, there is no short or simple answer since local political conditions and personalities must in practice also be taken into account.

Chapter 5: TRANSPORT AND URBAN FORM

The third main field for urban transport improvements is perhaps the most fundamental, the achievement of urban physical patterns which economize on costs of transport and other infrastructure but provide improved access and living conditions. In developed countries where changes in urban land use may amount to not more than 1% or 2% a year, and where existing infrastructure is very large as compared with annual additions, changes in urban form can be considered as essentially long-term in nature. In the cities of developing countries, land use change is many times more rapid, and urban area and infrastructure often double in less than 10 years. The situation is thus radically different. Opportunities exist for greatly altering physical urban patterns within a few years by closely relating the expansion of urban transport facilities with other measures for promoting desired patterns of land use.

The physical patterns of the cities of developing countries are, like those of the developed countries, largely characterized by a central business district which accounts for a high proportion of total employment—even though this district may be less well demarcated or concentrated than in the developed countries and contain a lower ratio of office to other activities. At the focal point of the transport system, the central business district has the highest accessibility of the city area both in terms of ready access from anywhere in the city and indeed places outside the city, and in terms of proximity of one business to others. More and more activities tend to locate there so long as the great advantages of accessibility are maintained.

Laissez-faire policies accentuate tendencies to centralization. In particular, enlarging transport capacity to cope with already emerged demands is likely to reinforce the relative accessibility advantages of the city center. Particularly, in conditions of infrastructure backlog typical of the cities of developing countries, further demand is created wherever new capacity is provided as people and businesses locate to derive benefit from the improved facilities. What tends to occur is an urban pattern based upon an increasing number of radial roads like the spokes of a wheel. Such a pattern promotes concentration on, and congestion in, the central business district. In the process, rents in the central area become too high for residences, particularly of the poor, while low-density residential development at the periphery is encouraged, including areas of high income housing largely dependent on automobile transport. Difficulties are created for cross-town traffic. Commercial traffic experiences increasing difficulty in avoiding the congested central area. Despite the congestion there, however, no other district has comparable access.

It is not at all evident, particularly in developing countries and despite the obvious advantages gained by concentration of activities, that the predominance of the central business district is justified to the extent found in the large cities. Most individual decisions to locate in the central area are based on expenses which do not reflect the full costs involved, including adverse impacts on others. The pricing of urban services such as water and sewerage, or electricity and telephones, are rarely differentiated sufficiently to reflect the varying costs of supply in high- and low-density areas, near and far locations. Similarly, a decision to build a new office block in the central business district does not reflect the cost imposed on others through additional congestion and pollution. Betterment charges and land property taxes are not in practice adequate substitutes.

As the cities rapidly grow in size, many activities found in central business districts no longer need access to all parts of the city. For many businesses, a smaller activity center with a transport network serving a smaller population area and containing a small range of activities would suffice just as well. Indeed, such a location, if available and with lower rents, would often be advantageous. Secondary centers do indeed tend to emerge in the course of time. They are favored where land use constraints are enforced on central district buildings and where alternative transport focal points are availabie—as in many North American cities where extensive suburban road networks are combined with the mobility of private automobile transport. In a few cases, such as Croydon in the metropolitan London area, the development of a subsidiary center may be carefully planned and promoted. More frequently, selection of location is haphazard, but becomes self-reinforcing as in the case of the main city center.

For the developing countries the problem posed by the predominance of the central business district and lack of secondary centers with adequate transport networks are much graver than for the developed countries due to lack of resources and competing claims. The tendency toward a predominant single central district not only imposes long average trips but also means that the transport needed to support its growth is, as has been noted, progressively more expensive. With capital so scarce, it is *prima facie* undesirable that the transport infrastructure should frequently be used intensely in only one direction at peak hours with large surplus capacity in the opposite direction. That so much of the transport and public utility facilities is concentrated in the central area and, in many cases, is largely unused out of office hours on weekdays and at weekends also raises questions of the appropriateness of the system.

What is, in any case, clear is that the multimillion cities of poorer developing countries cannot possibly afford the expressway and subway infrastructure required to support the degree of employment concentration in central business districts typical of major metropolitan areas in most of the developed world. Even if transport costs are economized by emphasis on public transport on ordinary roads with perhaps a few busways, the transport network costs and capacities will impose a maximum employment capacity of city centers at a much lower level than in developed countries which can afford more expensive very high-volume mass transit systems to supplement normal road traffic. The question of where other employment is to locate and of which type is, therefore, unavoidable.

In brief, the acute shortage of resources in the developing countries makes it much more urgent than in developed countries to devise less costly urban structures than the predominant single business district, automobile-oriented urban patterns of developed countries —while sacrificing as little as possible of the advantages of productivity to be derived from specialization and close proximity of related activities.

The Achievement of Better Urban Patterns

There is no simple solution to the question of what is the best urban form for the developing countries. Even if it were possible to start afresh from a "green field" situation, the functions of cities vary too greatly to permit a single optimum pattern. What is appropriate for a relatively small industrial city based, say, on a steel plant will vary from one that is primarily a government center or from a metropolitan city area encompassing a wide range of functions. Differences in income levels, customs and aspirations similarly require different solutions. The immediate needs and resource limitations of an Indian city are further removed from those of the richer Latin American cities than the latter are from those of European cities. Physical location and climate dictate other variations. Moreover, the existing city patterns strongly affect what can and should be done in the way of future expansion. In the developing countries much more than in the developed, care needs to be taken not to waste existing capital. Schemes involving extensive reconstruction should be treated with caution.

In the absence of a general optimal pattern, emphasis needs to be placed on promoting urban structures which meet specified desired criteria through urban expansion from the existing city layout; attempts to detail physical layouts of general applicability are likely to be much less productive. This is not the place to discuss in depth the many considerations involved in determining appropriate urban structures to relate the very varied urban activities to the chosen objectives. The previous analysis, however, emphasizes certain aspects particularly relevant to urban transport.

A primary consideration for developing countries is that a reasonably close proximity of work and residence should be ensured, particularly for the poor. So far as is economically reasonable, poor families should be located within walking or cycling distance of employment centers. Possibilities of employment not only for the principal wage earner but also other members of the family need to be taken into account. The urban structure should also allow public transport to operate under favorable load and speed conditions. More generally, low population densities and consequent dispersed built-up areas should be avoided since, as noted earlier, higher densities can provide equivalent access with shorter street lengths, fewer motorized or urban rail trips, lower vehicle speeds and consequently lower road or track design standards.[1]

Easier urban freight movement must also be a major consideration. Often the major cities are ports serving large parts of the nation. Adequate access to port areas from the intercity road and rail network, or from industrial estates, may require special trucking routes to bypass the existing center. Truck terminals and loading areas, and wholesale and retail markets, are required at locations which are efficient in terms of accessibility and avoidance of congestion. Relocation of existing markets, often centrally situated for historic reasons and with inadequate capacity, is frequently needed. Particular attention also needs to be given to the location of additional business and government offices, educational establishments and the like for which a central location is not so very important but which cause heavy peak-hour traffic in congested areas.

In what way, and to what extent, these various considerations should be reconciled and reflected in detailed urban physical planning depends on many other factors, social as well as economic. The economic factors include the influence of higher densities on costs of residential and other buildings, and on costs of sewerage and other infrastructure. Such relationships vary considerably from locality to locality. Social factors include the importance attached to preservation of open spaces and historic districts. Some promising general

[1] *It is to be noted that high densities do not necessarily involve "high-rise" buildings.*

lines of approach, and some important elements of required policy changes of wide applicability affecting urban transport, can nevertheless be discerned.

For large metropolitan areas in developing countries, the promotion of new centers of activity near the present urban periphery deserves careful examination. Relatively high proportions of residences should be contained in their land use. To provide a sufficiently attractive level of accessibility, transport services radiating from the new centers need to be provided and also improved public transport to join the new centers to the existing central business district.

Multinuclear urban forms should indeed have many advantages for the developing countries. While promoting close location of major work centers and residences, they should also allow minor industry to be located within residential areas without loss of contact with the major centers. Peak-hour traffic flows on main arteries would be in both directions to a much greater extent than with a single business district; cross traffic to other areas should be absorbed more readily.[2]

More generally, population groupings of 75,000 or more can in principle, if planned to integrate employment and residences, form communities within a city with a large degree of self-sufficiency. By reducing transport to other city areas, overall transport needs would be substantially lowered. Where expansion of urban areas has incorporated small outlying centers, a basis may already exist for developing such new nuclei. An alternative approach is through "activity corridors" which should have many advantages for the operation of high-capacity, low-cost public transport. Given the urgency of urban problems in developing countries, much more determined efforts are now required to test the potential of such approaches in specific localities.

Promotion of new activity centers with adequate accessibility to attract at least a part of the activities crowding into the central business district requires, however, a high minimum level of investment in infrastructure including transport facilities to radiate from the new nodal points. As noted earlier, such facilities are available to a much lesser degree outside the central area than in the cities of developed countries where new activity centers can hence evolve much more easily.[3] It has also to be noted that an incremental approach will often

[2] *Economies should also occur through greater interchange of parking facilities.*

[3] *Similar considerations apply to the difficulty of establishing new regional growth centers in developing countries where existing infrastructure, including the transport network, is sparse.*

not suffice to attract enough businesses sufficiently quickly for their mutually supporting activities to develop satisfactorily. This feature, combined with the costs involved, makes it apparent that not more than one or two additional activity centers can generally be promoted at a time. Similarly, it is unlikely that individual businesses can readily break away from the central area, despite the increasing rents, without the help of appropriate land use and transport policies.

To remedy this situation and to use market forces to greater advantage, action at several levels is required. It is necessary to relate both urban land use regulations and urban transport development to the desired urban patterns; to ensure timely minimum levels of investment in chosen centers of growth; and to adjust charges or taxes so that costs to individuals more adequately reflect the full social costs involved. The following paragraphs consider these aspects in turn.

All towns have land use regulations but they are usually outdated and poorly implemented. In developing countries, limitations on administrative capacity no less than the rapidity of change make concentration on effective broad frameworks of control more productive than on detailed land use specification. Land use regulations need, in any case, to be supplemented by more positive action designating new growth centers and ensuring adequate infrastructure for them. As an interim measure, it may be desirable to introduce land use measures designed to preserve for the time being as high a level of residents in the central area as at present, for example, by increased restrictions on conversion of residential land to office building uses.

The use of urban transport to foster desired patterns of urban growth is closely allied to land use regulation. Transport has always a strong influence on location; but the weaker the land use controls, the more important is the role of transport policy and investment as a guiding force. New transport facilities, by increasing accessibility, provide a positive inducement to location of activities; restrictions on use of existing transport facilities, or refusal to expand them, can provide a negative one. Continuing city growth will require better public transport and further concentration of at least some activities in central areas. But caution should be exercised in making major improvements to central access routes. Unless accompanied by measures to make land use controls and planning more effective and by a conscious policy of promoting rational use of transport facilities, their effect may be to accentuate existing weaknesses in city structure.

The effectiveness of both land use regulations and transport facilities in promoting better urban patterns can be greatly helped by more appropriate pricing. Congestion charging and greater differentiation of prices of transport are of great importance in this respect, generally favoring employment concentration in central areas, but only to the point that is economically warranted. Public utility charges also need to be revised to reflect more accurately the differential costs involved. Property taxes provide a further wide field for relating charges more closely to the social costs and benefits involved. One possibility deserving closer attention is for a special tax on those businesses in central congested areas, such as many types of office work, where visitors during the day and local business trips by staff—an indication of the essentiality of the location—are low as compared with the staff employed.

At the local neighborhood level, much can be achieved by more careful layout of urban extension areas to reduce the lengths of surfaced roads required and to facilitate pedestrian, cyclist and public transport. In many cases, surfaced road widths can appropriately be limited for some years while new settlements grow, so long as rights-of-way and foundations are planned for subsequent upgrading. Though individual schemes for local roads are generally small, in total they amount to a significant proportion of road expenditure and thus justify a degree of attention to design cost control that is often lacking. Here as elsewhere, standards based on European or American practice and dominance of the automobile are often adopted when *shorter-life,* more economical standards and reserved ways would be preferable.

Difficulties of Methodology and Measurement

Achievement of more appropriate urban transport and urban patterns is seriously hampered by difficulties of evaluation. Costs of transport should clearly be assessed at an early stage in preparing urban physical plans and in the context of alternative urban patterns and prospects for future urban growth. All too often, physical transport relationships based on supposed needs are established with insufficient attention to the costs involved and possibilities of securing better alternatives by varying the urban form. Opportunities are thereby missed of major transport economies. The limitations of comprehensive urban physical plans for periods of 20 or more years into the future are by now increasingly recognized as is the need for less ambitious regulatory frameworks continuously adapted in the light of experience. But as yet there is little evidence of effective planning of public transport services and facilities for walking and cycling as the backbone of the transport system in new urban extension areas.

In part, the lack of effective consideration of alternative transport solutions and their interrelation with urban form and costs of urban expansion is due to problems of methodology and measurement. What cannot be measured is often ignored even though this may exclude social effects of the greatest importance. Conventional urban transport models, moreover, have basic weaknesses which stem largely from the intricacies of the transport network, the complexity of the factors influencing demand, and the sequential treatment of influences which are, in fact, interdependent. Congestion charging and other policy variables cannot be readily introduced, nor can the extent of suppressed demand and effects on traffic of acute congestion. In brief, the models are poorly adapted to major changes of urban form, function and transport modes. Periods of preparation generally exceeding two years, and high costs, typically well over $500,000, add substantially to the basic drawbacks of spurious accuracy.[4]

For the cities of developing countries, the abruptness and rapidity of change in social and economic structure must, in any case, greatly limit the usefulness of predictive methodologies. In such conditions, even in the unusual case of accurate time series being available, use of past relationships can readily lead to serious cumulative errors in projections. The small proportion of current built-up area and infrastructure in the next 20 years widens the probable degree of error. In brief, conditions prevailing 20 or even 10 years from now can be foreseen even less clearly than in developed countries.

A strong case accordingly exists for developing strategic models to provide in outline a series of widely differing alternatives of mutually consistent future patterns of land use, incomes and transport designed to meet minimum objectives. Such models do not yet exist in satisfactory form. But transport relationships derived from a variety of cities should be of considerable help in their development. Most of the different scenarios produced would be eliminated by examination of their policy and investment implications and the extent to which they meet or exceed the minimum objectives. To the remaining alternatives more complex tests, using parts of current methodologies and models but also incorporating greater attention to secondary effects and social impact, would then be applied.

In view of the inevitable uncertainties of the future, a premium should be given to solutions for which the immediate investment program would also reasonably serve other alternatives, or could easily be adapted to do so. The program should then be kept under review to introduce modifications as experience of actual development is gained.

[4] *Annex 7 gives a more extended discussion of problems of models and methodology.*

Such a process requires close coordination between planning units and other agencies, and also with the policy makers. Without some political consensus on the urban form desired, long-term urban transport investment decisions tend to be self-fulfilling in that they create the demand they are designed to satisfy. The requirements and opportunities provided in related sectors may also be ignored. For example, improvements in the telephone system may significantly reduce the need for business trips. Furthermore, it needs to be admitted frankly that there is no known way of accurately measuring all the considerations involved, let alone of welding them into a single measure that will provide adequate comparison between alternatives. Value and political judgments are inevitably involved in coming to decisions; these are too important to be left to either the economists or the planning technicians.

Care is particularly required in evaluating savings and losses of time. If current income distribution is considered to be perverse and it is the intention to improve it, then it is illogical to use levels of income of different social groups as the basis for evaluation of benefits and losses such as those of travel time. To value savings of leisure time of a poor man at one-tenth of leisure time savings of a man earning ten times more—as is often done in current methodology—implicitly involves value decisions which are, or should be, outside the responsibility of the urban planner or model builder. Such practices, and failure to test the assumptions, tend to lead to effective priority being given to the needs of automobiles in investment and policy packages. As pointed out in Annex 7, time savings must, of course, be calculated as an important part of benefits, and for purposes of establishing consumer choices; but the effect on the calculation of total benefits of using alternative values for time saved and lost should be made clear.

Chapter 6: ACTIVITIES OF THE WORLD BANK

The Bank's Experience

The World Bank has had little experience in the field of urban transport. Prior to 1972, several urban highways had been financed, but mainly as constituent parts of intercity highway projects. Experience in urban railways had similarly been limited to a few components of railway projects of wider scope. In preparing these projects, the need for greater attention to their impact on system-wide urban traffic and on land use, and to their social effects, became apparent. The severity of the institutional and coordination problems, the complexity of the issues, and the importance of relationships with more general urban planning problems, made it clear that future urban transport projects would benefit from more comprehensive treatment.

Since 1972, the Bank's interest in the urban transport sector has grown considerably. The assistance approved for three urban transport projects in 1973 and 1974—in Kuala Lumpur, Tehran and Tunis—is indicative of the growth. In addition to physical components of road building, traffic engineering, rehabilitation of bus and suburban rail undertakings, and repair facilities, all three projects have been associated with important reforms in preparation and coordination of urban transport programs. The projects are also providing technical assistance and studies to aid management reform and longer-term policy formulation in the context of the physical pattern of urban growth. More broadly, the projects have dealt with immediate needs but focused on longer-term issues.

The Bank has also recently acted as executing agent for the United Nations Development Programme (UNDP) in supervising urban transport studies in Singapore, Costa Rica and Bogota. Similar assistance is being provided in Abidjan, Istanbul, Bangkok and Amman. These studies involve several innovations. The Istanbul studies, for example, attempt some simplification of modeling to provide more rapid comparisons of broad transport/land use alternatives. Many other urban transport projects have been the subject of preliminary investigation.

The recent experience has demonstrated that wide opportunities do exist for viable improvements in urban transport, but has also shown the absence of satisfactory, well-prepared projects ready for early financing. In addition to severe management and coordination problems and weaknesses of methodology, problems of financial viability of public transport undertakings have proved extremely complex, sometimes being intensified by high-cost local assembly of vehicles. Problems of ensuring competitive pricing of supplies are also raised by small numbers of suppliers, potential economies from vehicle standardization and, in some cases, the specificity of design requirements consequent on characteristics of the existing transport system.

Above all, the experience so far has emphasized the importance of policy measures in achieving the full benefits of urban transport investments—as also the practical difficulties of adopting significant reforms. Though most evident in relation to policies concerning private automobiles, similar difficulties extend to the choice between types of public transport, including intermediate personal transport, and to land use regulation. Opposition to new policies, while largely of a political or social nature, also derives from absence of relevant experience, or convincing studies, demonstrating the benefits that might be secured.

A no less pervasive lesson has been the size of the inputs of expertise required in preparing projects and the accompanying policy measures. Long gestation periods appear inevitable due to the inherent complexities and the long-run importance of the decisions taken, not least the influence on the structure of urban development. The problem lies, however, even more in the shortage of expertise, locally and worldwide.

As a consequence of the complexity of the issues and the limitations of expertise, the burden on the Bank in the preparation and supervision of the projects has proved particularly great. Insofar as extensive studies and technical assistance are required both before project formulation and as an integral part of the projects in developing longer-term policies, this supervision burden is roughly doubled.

The most promising aspect of the experience so far has been the policy initiative engendered by project preparation and preliminary studies. Significant institutional and policy changes, including measures involving automobile restraint in congested areas, have resulted from these activities. The technical assistance and the studies incorporated in recent projects seem likely to result in further progress in these directions.

The Bank's Policy

The Bank's policy towards the urban transport sector was outlined in the *Urbanization: Sector Working Paper* published in June 1972.

What follows is essentially an amplification of the basic approach outlined earlier.

Major reasons for the hesitation in undertaking projects in the urban transport sector had been the size of the sector in relation to the Bank's resources, the difficulties of analysis and lack of expertise, the evident weakness of the institutions involved, and pricing and procurement problems. A contributing factor was the danger that projects for expansion of transport facilities would, directly or indirectly, largely serve the needs of the minority of the population owning automobiles with possible adverse impact on the pattern of urban expansion, general living standards and social balance.

On the other hand, the growth of the Bank's program in sectors such as agriculture, industry, intercity transport, ports and tourism, all of which add to the requirements for urban transport facilities and are dependent on them for full success, has made the exclusion of urban transport projects appear increasingly illogical. Cities spend more on the infrastructure and operation of urban transport, and will continue to do so in the foreseeable future, than on any other urban service. Waste and inefficiency in this expenditure cannot but have serious consequences not only on the quality and level of urban transport, but also on the efficiency of the whole urban and national economy. That the obvious deficiencies in this sector appear to be due in part to neglect by both national and international agencies gives added emphasis to this concern.

Perhaps the most cogent reason for involvement in this sector is precisely its vital interconnection with the wider aspects of urban development that cause many of the difficulties of involvement. Urban transport is in many respects a leading influence in determining urban patterns both physical and social. As such, projects and policies in this field lead directly into general policies and plans for improving urban structure and productivity, and reducing urban poverty. The favorable impact of the projects can accordingly be much wider than the direct benefits in the transport sector, not least in alleviating the conditions of the urban poor. In this connection, project packages for improvements in urban transport operations and reductions in underlying distortions are not only justifiable on grounds of efficiency but also in terms of social equity, since it is the poor who, lacking the finance for alternative means of accessibility, inevitably suffer most from the inefficiencies and distortions.

Despite, however, the strong reasons for Bank involvement, only a rather limited project program can be envisaged for the urban transport sector at the present time. This limitation stems less from the financial resources available—though the Bank's contribution will inevitably remain very small in comparison with total investments in this sector—than from the limitations of staff and consultants. The desirability of more experience in a new and very difficult field before any major expansion provides a further reason for caution.

As a consequence, Bank operations in this sector must be highly selective, and chosen for their potential demonstration impact and widening of experience. A pragmatic approach, in which results are monitored and programs and policies adapted in the light of the results, is also indicated if effective action is to be initiated without undue delay. It has to be recognized that in the circumstances of the great complexities of the sector and weak methodologies, it is simply not possible to evaluate all significant interlinkages and side effects. But this should not mean that action to secure greatly needed and obvious improvements is paralyzed by the search for a still better but elusive optimum solution.

Within these constraints, the most fundamental aspect of the Bank's approach must continue to be explicit recognition that policy development is at least as important as physical investment in the current situation of urban transport in developing countries. Accordingly, policy considerations must be given an essential role in the preparation of all Bank projects in this field. Similarly, in view of the serious inadequacies of institutions in this sector, the improvement of coordination and planning mechanisms, and reform of management of public transport undertakings, must be basic elements in the justification of the projects.

Current financial weaknesses make it necessary that close consideration also be given to measures to improve the financial viability of public undertakings in urban transport. It is recognized that subsidies may be justified. Nevertheless, in view of the importance of mobilizing resources, and in the interest of promoting efficiency, support of subsidies will require specific justification.

In brief, urban transport projects presented to the Bank will be considered in the context of their contribution, direct and indirect, to the wider problems of improving the basic urban transport system and the form of urban growth. Unless attention is concentrated on these longer-term interlinkages, attempts to solve the urban transport problems based on existing needs can easily aggravate the future situation.

In practice, this means that Bank lending for urban transport will be concentrated in cities where the authorities demonstrate willingness to consider and implement bold measures progressively to adapt their policies to the mounting pressures of rapid urban growth. It is not possible in the abstract to define what constitutes satisfactory actual or prospective progress in these fields of policy development, institutional reform and financial viability. It is obvious that policy changes in this sector involve not only serious difficulties but also inevitable uncertainties. In the field of efficient charging of road usage, no country has yet introduced a satisfactory scheme. There are few guidelines of experience. It would, therefore, be unrealistic to expect the rigor of a full congestion pricing policy to be adopted in a single measure even where differentiated pricing of other public goods and services to cover full costs is habitual. Nevertheless, in view of the wide dependence of the success of projects to improve public transport on appropriate road pricing and supplementary measures, a demonstrable willingness to advance in this direction, must be regarded as a *sine qua non* for Bank support of such projects.

Even more evidently than in many other sectors, neither the policies nor the institutions involved can be transformed in a period of a few months, not least because so many agencies and interests are involved. These considerations point to the need for extended programs of progressive improvements and also to two further aspects of Bank policy in this sector. The Bank is prepared to consider continuing relationships with cities in implementing a series of suitable urban transport projects combined with policy and institutional developments that maintain initial momentum. Furthermore, as basis for a continuing program, technical assistance for management and policy formulation, and further studies which may be necessary will be given consideration as an integral part of initial projects. The favorable impact of the Bank's association should thereby be considerably strengthened not only in the city concerned but also, through the demonstration of the potential for improvements, in others.

The Five-Year Program, FY1975-79

Against this background of general policy considerations and because of the length of time required to build up a pipeline of projects in this sector, a considerable part of the program for the fiscal years 1975-79 will consist of continuing studies and other preparatory work, and technical assistance. Physical projects seem likely to be limited to an average of probably two per year, rising perhaps to three per year by the end of the period. The program is expected to include further projects in two of the three cities to which urban transport loans have recently been made. However, given the small number of projects, only general indications of the balance and content of the project program can be given until the outcome of current studies and policy discussions becomes available.

In the perspective of promoting a continuing relationship, the precise area of initial Bank involvement is to be considered less important than the prospect for building an effective relationship that can be expanded over time to cover wider aspects of urban transport and urban planning. Nevertheless, the main areas of interest are sufficiently clear.

Priority will be given to projects supplementing basic transport systems directed primarily to the needs of the great majority of urban populations who cannot afford a private automobile, and for goods traffic. Consideration will accordingly be given to bus and urban rail systems, including vehicles, repair shops, terminals, and road and track improvements required for efficient functioning. To reach the smaller private and public enterprises providing communal transport services, help may be routed through financial intermediaries; technical assistance to build up suitable institutions for this purpose may be included.

Particular attention will be given to projects catering for the many cyclists and pedestrians who cannot afford even low-cost public transport. Facilities for pedestrians and cyclists are generally sufficiently modest in cost to be most conveniently included as components of more comprehensive projects; their importance is nonetheless high. Technical assistance on longer-term aspects of urban development is also expected to stress these modes of travel.

Projects to expand facilities for commercial traffic are likely to include road access to port and industrial areas, including routes around urban areas to avoid heavily congested districts. Linkages between interurban or arterial roads and local networks are particularly relevant. Improved terminal and goods transit facilities are also strong candidates for consideration, including freight terminals which economize on sorting and consolidation of goods shipments. Wholesale markets are expected to offer a similar interest.

Particular attention will be paid to the potential for extracting the maximum advantage from existing transport infrastructure by traffic engineering and management projects. These may be separate projects or components of larger projects.

The advantages of synchronizing action in several mutually reinforcing aspects of urban transport, such as measures to increase road capacity, expand public transport services and introduce physical and pricing restraints on peak-hour traffic, have been stressed above. In this context, consideration will be given in suitable cases to Bank participation in financing more generalized urban transport programs and also urban development programs in which urban transport is a constituent part.

The Bank is currently involved in urban transport studies in some 12 cities. New projects are likely to incorporate additional studies, particularly with regard to longer-term urban transport/land use policies and management, including location economies through integration of transport facilities into the planning of new urban extension areas. In consequence, the total of studies in which the Bank is involved is scheduled to increase even though the heavy supervision requirements of such studies are recognized.

Many Bank projects in other sectors, such as ports, airports, industry, public utilities, tourism and intercity transport have important implications for urban transport. It is not possible to assess all these projects for their impact on urban transport and urban physical form. But where such impact appears likely to be substantial, and particularly where cities are involved in which urban transport projects are contemplated, an attempt will be made to evaluate the impact; where such evaluation indicates it to be desirable, complementary projects in urban transport may be undertaken. Such activities will be conducted within the more general context of continuing efforts to expand the evaluation of all Bank projects in urban areas to include wider economic and social aspects of urban development.

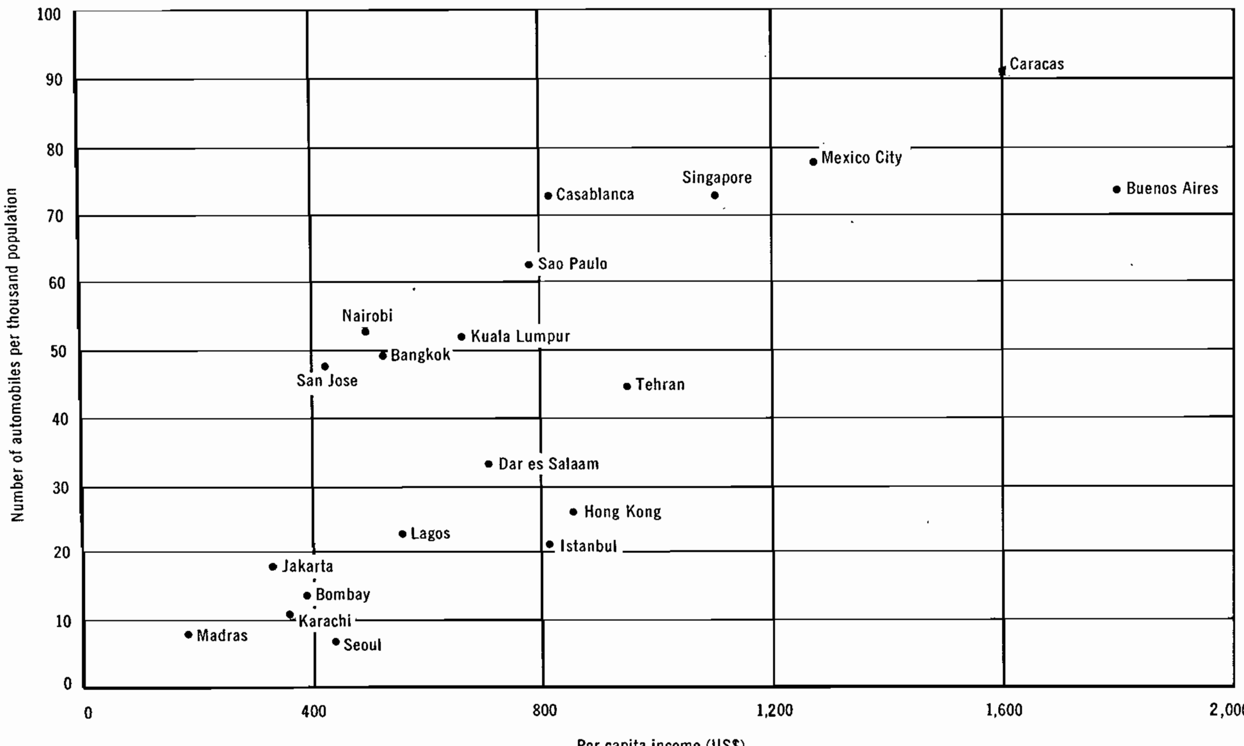
In view of the inadequacies of current methodology for analyzing urban transport problems and designing solutions, an attempt will be made to stimulate further development of methodologies specifically related to conditions in developing countries, though they are probably of much wider interest. The Bank's effort will be directed toward the integration of policy variables and alternative future conditions in simplified transport/land models, and to the more detailed assessment of the socioeconomic impact of chosen strategies. This may involve a more pronounced and leading role for the Bank in this field if it appears that the necessary skills to support the rest of the program in this sector will not otherwise be developed within a reasonable time. Operations research is also contemplated on the role of intermediate public transport in the provision of alternatives to both traditional bus services and the private automobile.

Monitoring efforts will be emphasized in view of present deficiencies in experience. As more project packages are implemented, it should be possible to benefit increasingly from experience and to reduce project preparation time. The Bank is already providing help in monitoring one ambitious urban transport scheme outside its own project program, that for supplementary central district licensing and other traffic restraint currently being undertaken in Singapore. Further research into practical experience in the urban transport field, in cooperation with several other agencies, is contemplated. In this connection, close links are envisaged with the Organization for Economic Co-operation and Development in studying practical experience in the introduction of various types of measures to promote more rational utilization of urban roads.

ANNEXES

Annex 1

Automobile Numbers and Income Levels



Source: Annex 2

Transport Data for Selected Cities

City	Population (1000) (1970)	Rate of growth of population (%) (1960-70)	Income per capita (US$) (1970)	Number of automobiles per 1000 population (1970)	Rate of growth of automobiles (%) (1960-70)	Number of buses per 1000 population (1970)	Number of commercial vehicles/1000 population (1970)	Import duty on economy cars (%) (Oct. 1974)	Import duty on luxury cars (%) (Oct. 1974)	Price of regular grade gasoline/US gallon (US$) (Oct. 1974)	Modal split of motorized trips (%)			Bus fare for a 3-mile trip (US cents) (Oct. 1974)
											Automobiles	Buses	Other motorized	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)			(12)
Calcutta	7,402	2.2	270	13.0	7.2	0.3	4.0	150	150	1.76	8	34	58(3)	3
Bombay	5,792	3.7	390	13.5	8.2	0.3	4.5	150	150	1.76	11	41	48(5)	3
Madras	3,438	4.5	180	7.9	5.8	0.6	1.9	150	150	1.76	—(1)	54	46(8)	3
Seoul	5,536	8.5	440	6.3	22.0	0.9	3.5	100	150	1.65	8	89	3(7)	—
Jakarta	4,312	5.3	325	18.0	8.8	1.1	4.3	200	200	0.44	29	49	22(9)	4
Hong Kong	3,350	2.9	850	26.2	7.1	2.1	7.0	—	—	1.10	22	55	23(2)	4-10
Karachi	3,460	5.6	360	10.4	(0.6)	0.3	—	300	150	0.89	16	63	21(8)	1
Tehran	3,600	7.0	950	44.4	(15.4)	1.0	6.8	30	62	0.35	37	42	21(7)	3-8
Bangkok	3,090	6.2	525	49.7	12.0	1.2	16.3	80	80	0.50	29	59	12(7)	5
Singapore	2,110	2.6	1,100	73.0	6.7	1.3	17.9	25	25	0.98	24	43	33(5)	6.5
Kuala Lumpur	755	6.5	660	51.9	11.3	1.0	21.8	35	60	1.40	47	35	18(7)	5
Mexico City	8,600	5.8	1,275	78.3	10.5	1.3	9.0	212	212	0.45	19	65	16(3)	—
Buenos Aires	8,400	2.4	1,800	73.9	(12.1)	1.6	25.6	140	140	1.29	17	60	23(6)	—
Sao Paulo	8,400	6.4	785	62.3	—	1.3	10.6	70	105	1.30	26	60	14(4)	—
Bogota	2,551	7.3	760	22.0	—	1.4	25.0	350	350	0.10	17	71	12(6)	2.5
Caracas	2,277	5.4	1,600	91.0	8.3	0.6	27.3	135	135	0.13	46	35	19(3)	—
San Jose	435	5.4	430	47.9	10.9	1.0	34.0	100	100	0.98	23	74	3(10)	4
Cairo	6,500	5.7	275	—	—	0.3	—	100	200	—	—	—	—	2
Istanbul	2,800	6.0	810	21.0	12.2	0.2	13.1	25	25	0.80	57	28	15(4)	10
Casablanca	1,505	4.5	820	72.9	(6.1)	0.4	26.1	120	120	1.46	—	—	—	10-20
Lagos	1,448	7.9	555	22.8	15.5	1.0	8.3	75	150	0.52	12	—	88(2)	—
Kinshasa	1,134	12.1	660	—	—	0.4	—	20	20	1.52	33	58	9(7)	6
Tunis	746	2.5	500	57.6	6.0	0.5	12.1	33	33	1.50	15	75	10(9)	1.5
Beirut	600	2.9	1,000	153.0	9.1	2.3	17.3	32	32	0.54	60	10	30(7)	6
Nairobi	567	8.1	495	52.7	(6.8)	1.5	40.6	40	100	1.12	72	28	—(7)	10
Abidjan	424	11.0	500	75.5	(12.7)	1.7	35.4	58	58	1.31	40	47	13(10)	5
Dar es Salaam	350	9.0	710	33.0	—	0.6	17.3	75	150	—	7	40	53(4)	3.5
Lusaka	225	3.1	660	45.7	—	1.1	22.1	10	10	—	66	7	27(6)	11

Tokyo	14,900	3.4	2,775	83.3	16.0	1.3	134.5	40	40	1.46	35	8	57[5]	25
London	10,547	−0.7	2,550	222.0	5.2	0.6	22.0	15.4	15.4	1.29	59	24	17[8]	25
Paris	8,448	1.3	3,530	248.0	6.5	0.4	44.4	11	11	1.40	36	21	43[2]	30
Athens	2,416	3.0	—	60.8	12.8	2.5	18.2	25	25	2.15	—	—	—	10
Washington, D.C.	757	−0.1	5,390	316.0	2.0	2.9	24.1	3	3	0.55	68	32	—[7]	40

(1) Included in "Other Motorized"
(2) Figures for 1965
(3) Figures for 1966
(4) Figures for 1967
(5) Figures for 1968
(6) Figures for 1969
(7) Figures for 1970
(8) Figures for 1971
(9) Figures for 1972
(10) Figures for 1973

Notes:

Because of the variety of sources, differences of definition and general weaknesses of collection, the data, though indicating orders of magnitude, have only limited comparability. Caution is accordingly required in their use. See following page for general notes and sources.

The data in the table were obtained from several publications indicated below, supplemented by information in various urban and transport studies available in the Bank. Information was also collected by World Bank missions and from government authorities. Since the sources and methods of data collection are extremely diverse, the table indicates only in rough measure conditions of urbanization and motorization.

Data for columns 1, 3, 4, 6, and 7 are for 1970, except in the case of a few cities for which data for 1969 or 1971 had to be used.

Rates of growth in columns 2 and 5 are for 1960-70, except for a few cities where growth rates were available for a shorter period only. Growth rates in parentheses are for the country and not the city.

For columns 8 and 9, a Toyota Corona was used to represent an economy car and a Mercedes-Benz 280 a luxury car.

In column 11, the data are for different years, depending on the most recent traffic survey available to the Bank. The different years are shown in the footnotes.

Sources:

United Nations, ***World's Million Cities,*** 1972 (for columns 1 and 2).

Motor Vehicle Manufacturers Association, ***Digest of Import Duties for Motor Vehicles Levied by Selected Countries,*** 1974 (columns 5 and 6).

Wilfred Owen, Brookings Institution, ***Automobiles and Cities—Strategies for Developing Countries,*** Bank Staff Working Paper No. 162, September 1973. Data supplied by Bank missions and government authorities (columns 10 and 12).

Lending Program for Urbanization, FY1970-74

(By fiscal year and subsector)

	FY1970		FY1971		FY1972		FY1973		FY1974		FY1970-74	
	US$ millions	Number	US$ millions	Number	US$ millions	Number	US$ millions	Number	US$ millions	Number	US$ millions	Number
Urban transport	—	—	—	—	—	—	16.0	1	60.0	2	76.0	3
Urban development	—	—	5.4	1	8.0	1	—	—	38.0	2	51.4	4
Sites and services	—	—	—	—	—	—	20.0	1	15.0	1	35.0	2
Urban studies	—	—	—	—	2.3	1	—	—	—	—	2.3	1
Technical assistance	—	—	—	—	—	—	—	—	8.0	1	8.0	1
Total	—	—	5.4	1	10.3	2	36.0	2	121.0	6	172.7	11
Percentage of total World Bank/IDA lending	—	—	0.2	0.8	0.4	1.4	1.1	1.4	2.8	3.5	1.3	1.9

Urban Lending Program, FY1969-74

Country	City	City population (millions)	Urbanization (including urban technical assistance)		Other sectors with direct urban impact(1): Power		Transportation		Water supply & sewerage		Other sectors with urban impact(1): Tele-communications		Industry		Development finance companies	
			US$ millions	Number	US$ millions	Number	US$ millions	Number	US$ millions	Number	US$ millions	Number	US$ millions	Number	US$ millions	Number
Botswana(2)	Francistown	0.02	3.0	1	—	—	2.0	1	3.0	1	—	—	40.0	3	4.0	1
Senegal(2)	Dakar	0.65	8.0	1	—	—	22.7	4	—	—	6.3	1	0.6	1	3.0	1
Iran(3)	Tehran	3.15	42.0	1	169.0	3	168.0	4	—	—	118.0	2	—	—	240.0	5
Tunisia(3)	Tunis	0.64	18.0	1	12.0	1	57.0	4	48.5	3	—	—	—	—	34.0	3
Turkey(3)	Istanbul	2.25	2.3	1	229.5	6	47.0	1	37.0	1	—	—	140.0	3	145.0	4
Malaysia(3)	Kuala Lumpur	0.74	16.0	1	31.5	2	51.6	3	17.1	2	23.1	2	—	—	—	—
India(3)	Calcutta	5.84	35.0	1	160.0	2	293.0	4	55.0	1	213.0	3	138.0	4	195.0	4
Guyana(2)	Georgetown	0.17	5.4	1	6.0	1	4.4	1	—	—	—	—	—	—	—	—
Jamaica(2)	Kingston	0.12	15.0	1	—	—	9.3	1	5.0	1	—	—	—	—	—	—
Nicaragua(2)	Managua	0.32	20.0	1	24.0	1	11.0	1	6.9	1	—	—	—	—	—	—
Jordan	Amman	0.50	—	—	10.2	1	6.0	1	8.7	1	—	—	—	—	—	—
Singapore	Singapore	2.10	—	—	20.5	1	—	—	18.0	2	11.0	1	—	—	5.0	1
Colombia(2)	Bogota	2.50	8.0	1	126.3	3	92.5	4	117.6	4	15.0	1	—	—	125.0	3
Costa Rica	San Jose	0.22	—	—	18.5	2	17.1	2	—	—	47.5	3	—	—	—	—
Ivory Coast	Abidjan	0.40	—	—	—	—	45.5	3	—	—	25.0	1	—	—	—	—
Brazil	Curitiba	7.00	—	—	484.9	8	357.0	6	73.0	2	—	—	242.0	4	25.0	1
Venezuela	Caracas	2.30	—	—	31.0	1	37.0	2	—	—	35.0	1	—	—	—	—
	Total		172.7	11	1323.4	32	1221.1	42	389.8	19	493.9	15	560.6	15	776.0	23

(1) Refers to lending to the country concerned.
(2) Countries which have received World Bank loans for urbanization.
(3) Countries which have received World Bank loans for urbanization and have ongoing World Bank urban studies.
Unnumbered countries have ongoing World Bank urban studies.

CHARACTERISTICS OF URBAN TRANSPORT MODES

In considering the characteristics of different forms of urban transport, it is necessary to consider both the rights-of-way and the use made of them. The analysis is complicated by the joint use of roads by many types of vehicles and by complementarities between them. Buses need pedestrian ways for passengers to reach them, urban railways need feeder services such as buses, automobiles require parking space, expressways require subsidiary roads to give access to individual buildings, and so on. It is necessary to consider the urban transport system as a whole.

The capacity of footpaths, roads and railways, or "track" for short, can most conveniently be considered in terms of the number of persons (or vehicles) that "flow" past a given point in a period of say an hour and their speed—the two are in fact closely related. Under most practical conditions, speed decreases as flow increases; the ratio of the flow to the speed gives the number of vehicles per unit length accommodated on the road. The number of passengers that a given length of track can accommodate usually increases as speed decreases (providing speeds are above a lower limit of about 5 miles an hour in the case of roads[1]). Conversely, high speeds, which require larger distances between vehicles and wider lanes, lower the flows and the number of vehicles and passengers a given area of track can accommodate—but, of course, enable those who are accommodated on the track to travel a longer distance in a given period or the same distance in less time. It is, therefore, flow multiplied by speed which most closely indicates the "output" or efficiency of the track. This "output" is in turn reflected in the time savings which constitute often the main benefit of a transport infrastructure investment.

One other preliminary remark on terminology may be useful. Since a bus evidently takes more road space than an automobile, it is often convenient to discuss road capacity characteristics in terms of passenger car units or PCUs. In the congested conditions of central urban areas a heavy truck or double-deck bus can typically be considered as roughly equivalent to about 3 PCUs, single-deck buses with shorter loading times to 2 PCUs and collective taxis to perhaps 1½ PCUs. Exceptionally slow or clumsy vehicles, such as bullock carts, may be equivalent to 6 PCUs or more. An analysis of actual conditions is, however, generally required to confirm PCU equivalents in specific

[1] *Below this speed, increased numbers of vehicles on the track reduce both flows and speeds until traffic may come to a complete standstill.*

study areas as the degree of congestion and level of speeds appreciably affects the PCU values.

The following paragraphs consider the characteristics of pedestrian traffic, and cyclists on bicycle tracks. Road transport is then considered in terms first of the roads and then the vehicles that use them. Next passenger transport on separate rights-of-way, such as urban railways and busways, are discussed. A final section considers some of the wider aspects of the urban transport system as a whole including congestion costs.

To avoid repetition, many points dealt with in the main text are not again treated here. It should be emphasized that all figures given are illustrative only. Though derived from actual conditions in urban areas, and although broad relationships are often remarkably similar from city to city, local conditions vary too greatly for the data to be used as a basis for decisions on individual situations. Costs are given throughout in U.S. dollars or cents.

Pedestrian Footpaths

A footpath can carry more people per foot of width in an hour than any other form of track except exclusive bus or rail track. As indicated in Table 5:1, about 1,100 persons can be accommodated at an average speed of 2.1 miles an hour; as many as 1,200 can be accommodated at a speed around 1½ miles an hour. Pedestrians can walk very close to each other, even in opposite directions, make turns or stop without seriously interfering with flows, at least up to the levels indicated.

The disadvantages of walking are obvious. Speeds are low, less than 3 miles an hour, and comfort in hot weather or rain is at best poor. In crowded conditions, speeds and flows may be substantially reduced and discomfort raised. Low speeds and fatigue in any case effectively limit pedestrian trips to about 2 miles in most cities though longer distances may prevail for poorer groups of the community. Nevertheless, the total passenger-miles traveled in an hour is much greater per foot-width than can be achieved by automobiles at normal town speeds, and is in the same range as can be achieved by bus.

Costs of track per foot of width are much less than for other modes, comprising mainly costs of land; construction costs are very low. Since there are no operating costs to be taken into account except a small expense for shoes, etc.,[2] walking stands out as by far the cheap-

[2]For both walking and cycling an allowance should theoretically be made for additional food intake required when using these modes. This, however, is likely to amount to only a fraction of a cent a mile.

Illustrative Costs of Urban Travel by Different Modes

	Speed (miles per hour)	Persons per foot-width[1] per hour	Track capital costs[2] Per hour	Track capital costs[2] Per person	Track maintenance costs[3] Per vehicle	Track maintenance costs[3] Per person	Vehicle operating costs[4] Per vehicle	Vehicle operating costs[4] Per person	Total costs per person
			US cents per mile		US cents per mile		US cents per mile		US cents per mile
Footway, 4 feet wide	2.1	1,100[5]	2	0	0	0	0	0	negligible
Bicycle track, 4 feet wide	8	450	50	0	0.3	0.3	0	0	0.3
Urban street, 24 feet wide, mixed traffic									
Car with driver only	15[6]	29	120	4.1	0.4	0.4	13.0	13.0	17.5
	10	51	120	2.4	0.4	0.4	14.6	14.6	17.4
Taxi with 4 passengers	12	120	120	1.0	0.4	0.1	13.6	3.4	4.5
	8.6	200	120	0.6	0.4	0.1	15.4	3.8	4.5
Minibus with 10 passengers	10	150	120	0.8	0.6	0.1	20.0	2.0	2.9
	7.5	250	120	0.5	0.6	0.1	24.0	2.4	3.0
Bus with 30 passengers	8.6	300	120	0.4	1.0	0	50.0	1.7	2.1
	6.7	500	120	0.2	1.0	0	60.0	2.0	2.2
Urban street, 44 feet wide, mixed traffic									
Car with driver only	15[6]	39	120	3.1	0.4	0.4	13.0	13.0	16.5
	10	55	120	2.2	0.4	0.4	14.6	14.6	17.2
Taxi with 4 passengers	12	160	120	0.8	0.4	0.1	13.6	3.4	4.3
	8.6	220	120	0.5	0.4	0.1	15.4	3.8	4.4
Minibus with 10 passengers	10	190	120	0.6	0.6	0.1	20.0	2.0	2.7
	7.5	280	120	0.4	0.6	0.1	24.0	2.4	2.9
Bus with 30 passengers	8.6	410	120	0.3	1.0	0	50.0	1.7	2.0
	6.7	550	120	0.2	1.0	0	60.0	2.0	2.2
Urban expressway (capacity per foot-width is independent of width)									
Car with driver only	40	180	900	5.0	0.4	0.4	11.0	11.0	16.4
Taxi with 4 passengers	40	720	900	1.2	0.4	0.1	11.2	2.8	4.1
Minibus with 10 passengers	40	1,200	900	0.8	0.6	0.1	17.0	1.7	2.6
Bus with 40 passengers	40	2,000[7]	900	0.4	1.0	0	43.0	1.1	1.5
Metro (22,500 passengers per hour)	21	1,700[7]	4,400[8]	2.6	43.0	0.7	37.0	0.6	3.9
Urban railway (22,500 passengers per hour)	30	1,700[7]	1,600[8]	0.9	43.0	0.7	37.0	0.6	2.2

Note: For footnotes, see following page.

(1) This column is adapted from Professor R. J. Smeed's presentation in "The Traffic Problem in Towns" (Manchester Statistical Society, 1961), with the data on road capacities updated by him on the basis of more recent work by J. G. Wardrop. PCU values assumed:

	Urban Street	Expressway
Car	1	1
Taxi	1	1
Minibus	2	1½
Bus	3	2

(2) Track costs per hour, which are subject to wide variation, have been calculated on the basis of a 2,000-hour per year track utilization, infinite track life, and a 12% per year interest charge. Figures given are for a strip one mile long and one foot wide. Urban street is assumed to cost US$240,000 and urban expressway US$1,800,000 per 12-foot lane-mile, inclusive of land and all services. Capacity of expressway is assumed to be 2,200 PCU per lane per hour.

(3) Maintenance costs are assumed sufficient to keep track in good condition indefinitely, and also include the costs of lighting, cleaning and traffic control. Figures are based on data collected by Alan M. Voorhees and Associates in the Bank-financed Caracas Road User Charges Study.

(4) Vehicle operating costs, which include depreciation and interest charges, are also subject to wide variation. The 13 cents a mile for a car represents a U.S. "compact" car under relatively favorable road conditions. Taxis are assumed to have the same costs as cars, plus drivers' wages of 70 cents an hour. Minibuses are represented by the 14-seat Hong Kong "Public Light Bus" and costs are adapted from Richard Butler's *Bus Operation in the Colony of Hong Kong.* Bus costs are assumed as in Kuala Lumpur's 40-seat buses, as calculated by Wilbur Smith and Associates. Railway operating costs, which relate to London, are supplied by London Transport. Speed reductions from 15 to 10 miles per hour are assumed to raise operating costs by 12% in the case of cars and taxis, 15% in the case of minibuses, and 20% in the case of buses. Speed rises from 15 to 40 miles per hour are assumed to result in vehicle operating cost savings of 15% in all cases.

(5) Data on footways are obtained from "Movement of Pedestrians on Footways in Shopping Streets" by S. J. Older, *Traffic Engineering and Control,* August 1968.

(6) Mixed traffic on urban streets are assumed to move at 15 or 10 miles per hour. Taxis are assumed to stop 1 minute, minibuses 2 minutes, and buses 3 minutes per mile traveled.

(7) Bus-on-expressway figures are based on observations on the I-495 bus-lane leading to the New York Port Authority bus terminal, recording 597 buses in one hour. Higher rates of flow were observed over five-minute periods. Railway passenger flows are based on conditions on Mexico City's Metro, overall average loadings are assumed to be 62 people per car compared with 16 in London. These volumes should not be taken as maximum capacities of mass transport: passenger flows in excess of 60,000 per hour have been observed in New York and Tokyo subways, under conditions of crush loading. Similar volumes of passengers, even all seated, could be moved by high capacity buses on exclusive lanes. Few traffic corridors generate such volumes.

(8) Metro track is assumed to cost US$8,000,000 per lane-mile, as in Mexico City. Urban railway line is assumed to be at ground level and to cost US$3,000,000 per lane-mile.

est mode of travel and one of great capacity in terms of the limited space requirements.

Cycle Tracks

Bicycle tracks are also relatively inexpensive to build. Under favorable conditions they can achieve a flow of persons per foot-width of about half that of a pedestrian footway. This is still considerably higher than the flows achieved by automobiles or roadways—except perhaps for fully loaded automobiles on motorways—and of the same order of magnitude as achieved by buses in mixed traffic. At speeds of about 8 miles per hour, the total hourly "output" of travel produced by this track, i.e., the product of flow and speed, can reach 3,600 per foot-width. This level of efficiency or "output" easily exceeds that of automobiles except on motorways, equals that of buses and is nearly twice the rate for pedestrians on footpaths. Operating expenses are very low, amortization of the bicycle, tires, etc., amounting to only a fraction of a cent per mile, while parking and other requirements are negligible as compared with motorized traffic.

The range of cycling is probably about 8 miles, sufficient for most journeys to work. Minimum efficient track width is no more than 2.5 feet for unidirectional and 5.5 feet for two-directional bikeways. Overcrowding, particularly on two-directional tracks, can reduce speeds and flows below those indicated in Table 5:1.

Cycle tracks offer a great potential for the developing countries in reducing public outlays for transport infrastructure, particularly if means can be found for encouraging bicycle use by better supply and financing facilities. Cycle tracks do, however, cause serious difficulties at intersections. Penetration of cycle tracks into central areas, unless planned from an early stage of growth, may be difficult to incorporate at a later stage.[3]

Urban Roads

The characteristics of urban roads, including capacity and costs, vary greatly with the locality and standards of the roads and the types and numbers of vehicles they are designed to carry. For a given urban road, as traffic grows, the hourly flows rise, but speed falls, at first slowly and then more rapidly. At automobile speeds of around 10 miles an hour, a maximum level of road output per mile is reached.

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[3]*See, for example,* Bikeways Planning Criteria and Guidelines, *Institute of Transportation and Traffic Engineering, University of California, 1972, for additional detail on cycle tracks. The range of cyclists is here placed somewhat above the range in most developed countries but information is scarce. Flat land obviously increases range and sharp gradients deter use.*

With further increases of traffic, flows increase more slowly and speeds decrease more rapidly.

Taking typical conditions of mixed traffic on a two-lane, two-way 24-foot urban road with typical automobile speeds of 10 to 15 miles an hour and similar conditions on a 44-foot normal arterial road with two lanes in each direction, it can be seen (Table 5:1) that the four-lane road provides considerably higher flows per foot of width than the two-lane road. This is because traffic moving at higher speed can more readily separate from slower traffic or vehicles stopping to alight passengers or goods. In severe congestion, this advantage is much reduced. Other things being equal, road widening from two to four lanes is, therefore, likely to be more economical than building a separate two-lane road of similar type.[4] Also more vehicles, and hence passengers per hour, can be accommodated as speeds of automobiles fall from 15 to 10 miles an hour.

On an urban expressway, flows per foot-width almost three times higher than on the four-lane arterial road can be achieved. This is largely because there are no intersections—intersections have only about half the capacity of the roads leading to them—and slow traffic and parking are prohibited; vertical and horizontal curves are gentle, allowing safe overtaking. As a result much higher speeds are possible. Access directly from expressways to buildings is, however, not permitted so that urban expressways necessarily require local roads to supplement them, and the exclusion of parking and slow traffic means that alternative facilities are required for these purposes.

Because of the wide variations in conditions between cities, it is difficult to give typical figures for urban road costs. Both construction and land costs rise the nearer the road is to the center of the city due to the scarcity of land, difficulties of access and costs of destruction and reconstruction of property, utility lines, etc. For example, recent estimates of expressway costs in Kuala Lumpur indicate a fourfold increase in unit cost as the distance from the city center falls from 4 to 0.5 miles.

Simply to indicate orders of magnitude, a four-lane urban arterial road may cost less than $50,000 a lane-mile, or $4,000 a mile per foot-width of paved surface in outer urban areas, whereas costs of urban expressways in central areas may reach over $1.7 million a lane-mile or $150,000 per foot-width/mile in cities such as Caracas, Lagos and Kuala Lumpur, to judge from recent experience. A $150,000 a mile per foot-width total, including land, may translate into costs of

[4] In the early stages of expansion of urban areas—or in intermediate areas as cities expand —there may, therefore, be initial economies of scale with road expansion.

about 5 cents a vehicle(PCU)-mile at a conservative 12% allowance for interest and depreciation and high rates of utilization.[5] By contrast, at $20,000 a mile per foot-width, which is much more typical of normal urban arterial roads away from the central district, the cost per vehicle(PCU)-mile is likely to represent only about half that of the expressway despite the much smaller rate of traffic flow. For comparison, taxes on automobiles equivalent to 50% of import price plus 50 cents per gallon of gasoline may work out at about 3½ cents per vehicle-mile for an automobile covering 20,000 miles a year—well below the costs of the central expressway though above those of the outlying roads.

Maintenance costs of urban roads are, in comparison with capital costs, very low but not insignificant. They comprise traffic control, road repair, lighting, cleaning, etc. To illustrate the order of magnitude, a study in Caracas in 1971 estimated maintenance costs at 0.4 cents an automobile(PCU)-mile or 1 cent for a bus.[6]

Operating Costs of Road Transport Vehicles

The "running costs" of operating motorized road vehicles, such as fuel and tire costs that are incurred only as a result of the vehicle moving, vary with the speed of the vehicle. Running costs are generally lowest at speeds of 30 to 40 miles per hour. In conditions of congestion, at speeds below 20 miles per hour, running costs often increase roughly in proportion to changes in journey time. The diagram showing vehicle operating costs at different speeds is taken from conditions in Singapore to illustrate this point. Other costs of operation, including capital costs, administration and paid drivers' time may also be influenced by speeds, but generally to a much less significant extent.

Automobiles

With two persons traveling—a typical average for many cities in developing countries—the automobile is relatively expensive in terms of road space used. As illustrated in the examples given in Table 5:1, the flow of persons an hour per foot-width of road is well below other modes. This is fundamentally because an automobile, while

[5] This would be the cost if attributed to 2,000 hours per year of flows of 180 vehicles (PCUs) per hour per foot-width. With the allowance for maintenance discussed in the following paragraph, it is assumed that the life of the roadway is infinite and hence depreciation is negligible.

[6] Alan M. Voorhees and Associates. An earlier London study gave similar results including also 1.35 cents for a truck-mile.

requiring only about a third of the road space of a bus in congested conditions, carries very much less than a third of the passengers. Even though the automobile travels almost twice as fast as a bus on congested roads, this is not sufficient to offset the difference in load carried; total passenger distances achieved in an hour are well below those for buses. On an urban expressway, the higher speeds and separation of traffic permit the hourly passenger-miles achieved by automobiles per foot-width to rise several fold; but a bus using the expressway will achieve a similar increase.

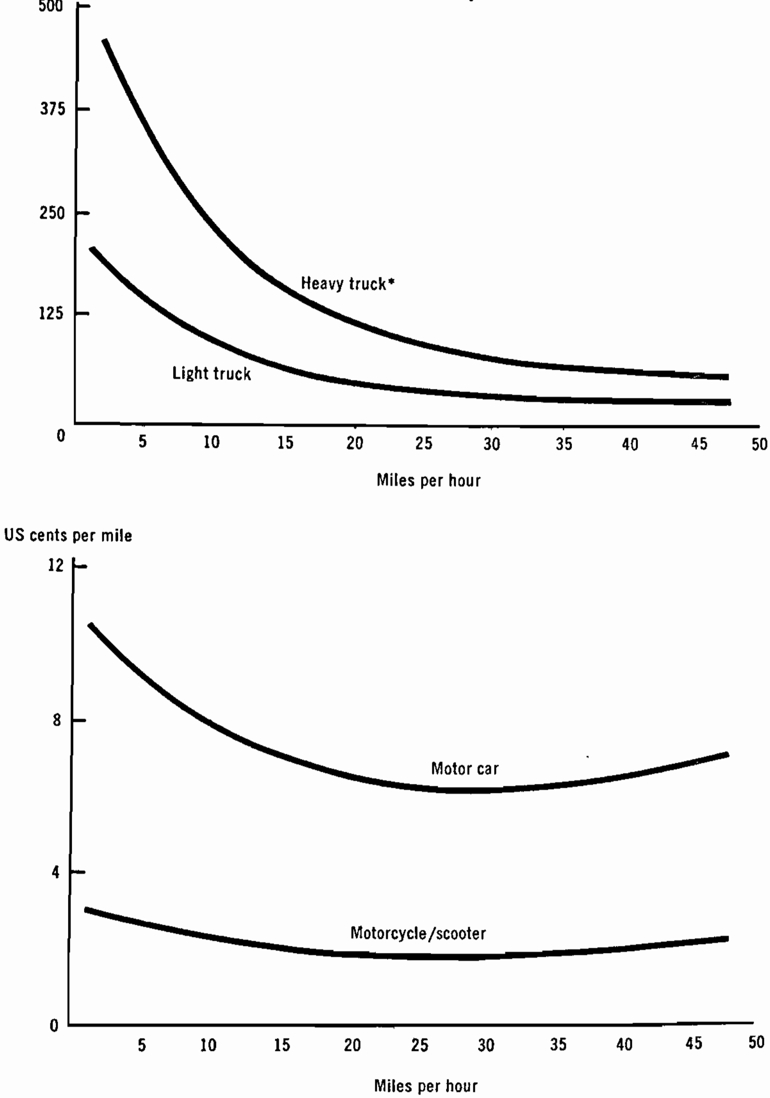
Costs of operating an automobile in developing countries are now typically somewhat in excess of 15 cents a mile in relatively congested conditions and with speeds averaging around 10 miles an hour. There is a small improvement in total operating costs at speeds of 15 miles an hour and on urban motorways the operating costs may come down to around 12 cents a mile at an average speed of 40 miles an hour before rising again at higher speeds. This means, since only a part of travel can be on an urban expressway, the costs per automobile passenger for an average of two persons per automobile are likely to be in the 6 to 9 cents a mile range but can fall to 3 or 4 cents a mile if the car fills up with four passengers.

These totals of automobile costs exclude any allowance for the cost of the road which, as has been noted, may vary from little over 2 cents a vehicle-mile in outlying urban areas to 5 cents a mile for an expressway near the city center or 1 to 3 cents per passenger-mile at average loading. Nor are the costs of parking included. If automobiles are parked on the road, and take 100 square feet of space, then the cost per hour may amount to 20 cents in central areas of cities such as Bangkok, using a land rental value of 10% and 4,000 hours of use a year as base for the calculation.

Jitneys and Minibuses

Next in size in terms of passengers carried and road space required per vehicle are the various types of jitneys and minibuses. Those based on modified automobiles have many characteristics similar to automobiles. Road space requirements per vehicle are, however, a little higher because of more frequent stops, which also lower average speeds; but because of the higher number of passengers carried (usually not far short of the full capacity of five) road requirements per passenger are substantially less than for the automobile though still above those of the bus. This is reflected in the figures of flow of persons per foot of road-width given in Table 5:1.

Vehicle Operating Costs at Different Speeds



*Also indicative of variation of bus costs with speed.

Source: Wilbur Smith and Associates, *Singapore Mass Transit Study*, 1974.
Cost figures are for 1972.

Operating costs per vehicle-mile of jitneys are increased by the remuneration of the driver as compared with the automobile but these costs are shared by a large number of passengers per day. As the vehicles are, on average, operated for many more miles than private automobiles, capital costs per mile per passenger are much less than for the automobile. On balance, total costs per passenger-mile work out at substantially less than for an automobile but can be above those for the bus—where capital and driver costs are shared by a substantially greater number of passengers.

Minibuses are at present used on a large scale in relatively few cities though the trend is upward. In terms of passenger capacity, they provide a convenient half-way house between the automobile or jitney and the regular bus. Costs are similar to those of jitneys. Like the automobile and jitney they can penetrate into areas that a regular bus cannot, and also operate efficiently with far fewer passengers. In outlying areas these forms of collective transport have therefore considerable advantages. But in central areas their greater road space requirements per passenger as compared with buses are a disadvantage. Costs of the road space required per vehicle, about one and one-half times that for an automobile, work out at up to 3 cents a passenger-mile for jitneys and 1 cent a passenger-mile for minibuses on normal arterial roads.

Buses

The road requirements of buses in mixed traffic vary considerably according to traffic conditions but something less than 3 PCUs seems typical. They can, and in rush hours often do, carry as many as 70 passengers, or 120 passengers on the new double-decker buses that are used in Hong Kong. Even with 40 passengers, buses can achieve flows of over 500 persons per hour per foot-width of road. Speed is very sensitive to the time taken at stops for passengers to board and alight. In practice, average commercial speeds much above 8 miles an hour for regular bus services are rare. Close attention is, therefore, warranted to the potential for limited stop express buses which can achieve speeds more closely comparable with those of automobiles, with consequent saving in running costs as well as in passengers' time. Reserved lanes for buses can increase their speed up to 17 miles per hour in some instances. On urban expressways, bus speeds often approximate those of automobiles.

Costs of bus operation are largely affected by costs of labor, both actually on the buses and for administration and maintenance; these vary substantially from country to country. However, on the basis of several recent estimates, it appears that total costs of the order of 50 to 75 cents a vehicle-mile or a little below 2 cents per passenger-mile are typical in many developing countries. Under conditions of congestion the higher level of passenger loadings may compensate for higher operating costs per bus.

Costs of road requirements per passenger for buses are much lower than for other passenger transport vehicles. Even at the top level of road costs of 5 cents per PCU vehicle-mile, the cost per bus passenger-mile is below 1 cent in the typical situation of loadings above 30 persons; at the lower end of the scale, road costs fall below one-tenth of 1 cent. Parking costs are also much below those of automobiles.

The relatively large capacities of buses as compared with other road transport vehicles and low road space requirements per passenger—even when half full—make buses particularly suitable for service along heavily populated corridors where reasonably full loads at short frequencies of service can be obtained. On expressways, their speeds can rise substantially and their costs fall correspondingly.

Separate Track Systems

The great advantages of separate track transport systems is that interference from other traffic is largely removed, permitting higher speeds with increased safety. Their disadvantages are twofold. First, the minimum width of track feasible provides a very large capacity which, in the absence of other traffic, is difficult to utilize fully; capital costs of track per passenger accordingly tend to be high. If tunneling is involved, track costs are very high. Second, once track location is determined, this part of the transport system is largely inflexible and can only with difficulty be adapted to changing conditions. Taken together, these two features tend to mean that subsidiary, smaller capacity feeder services are required involving transfers and consequent loss of passenger time.

Railways

A surface urban rail line, providing 20 to 25 eight-car trains an hour, can handle a unidirectional crush condition flow of over 60,000 passengers an hour. This is equivalent to well over 4,500 persons per foot-width per hour[7] though in normal conditions for the system as a whole, only about one-half of these levels would be typical. Even so this is about eight times the capacity of automobiles carrying a

[7] *The estimate is based on Tokyo experience of 300 people per rail car and a train capacity of 2,400.*

typical passenger load on motorways, and four to five times bus capacity in typical mixed traffic. A single train capacity of over 600 passengers is itself so large as to limit service frequencies outside peak periods. Average speeds and overall capacity are to a great extent determined by the spacing of stations since, due largely to the heavy weight of trains and the use of steel wheels on steel track, braking power is relatively poor. Accordingly, acceleration and deceleration are slow and large distances are required between trains for safety. Even in unusually favorable conditions with stations one mile apart and stops averaging less than a minute, average speeds may be not much above 20 miles an hour, even if the top speed is 50 miles an hour.

Unfortunately, data on capital costs of surface rail track in current conditions in developing countries is too scanty to be of much use as most rail tracks were laid many years ago. Moreover, local conditions of passenger volume over different hours of the day, particularly the volume in off-peak hours relative to peak hours, are of paramount importance in determining railway costs per passenger mile. Conditions of physical terrain are also important: high gradients and sharp curves can be accommodated only at considerable expense. Such features need to be closely investigated before any assessment can be made. But it seems probable that where conditions are favorable, including passenger volumes that are very heavy over long periods of the day, expansion and extension of urban railways may provide personal transport at costs per passenger-mile at least comparable with those of buses in mixed traffic and with low space requirements. Often, however, a more appropriate comparison will be with busways considered below.[8]

Where tunneling is involved as in metros, costs of rail track rise sharply. Subway costs vary greatly according to the difficulty of tunneling but are rarely much below $10 million a lane-mile and can easily exceed $25 million. Including above ground portions, the recent Mexico City metro cost over $8 million a lane-mile. Capacity and maximum speeds are similar to the urban railway but somewhat closer headways may be obtained with the lighter vehicles, more rapid loading and more elaborate signaling and safety devices. Even so, it is difficult to lessen headways between trains below 3 minutes. It is moreover very difficult to introduce limited stop subway trains

[8]There is no space here to consider streetcars and other forms of light urban railways with partially separated rights-of-way to offer considerable potential, particularly if times of stops can be reduced, for example by platform loading; nor the potential for converting rail track to routes reserved for buses.

since costs of providing passing loops are likely to be prohibitive. Passengers per hour can theoretically reach 60,000 assuming 200 cars an hour at crush loadings of 300 people, or between 4,000 and 5,000 per foot-width.

The advantages of underground metros are clear. Fast and with very high capacity, they greatly reduce the surface area needed for transport in the most congested districts. If the aim is to perpetuate high density central areas, subways may provide the only solution. They are however expensive. To judge by the recent experience in Mexico City and preliminary estimates elsewhere, fares will need substantially to exceed 10 cents for an average trip of two or three miles if full costs are to be covered—even where very high density traffic is encountered. This feature, and the high initial capital costs involved, largely explain why only two cities in the developing countries at present possess major metro systems—Mexico City and Buenos Aires.[9]

Busways

One alternative to the metro or surface railway that is receiving increasing attention is the segregated busway. Track construction costs are likely to be appreciably less than for an urban railway, unless tunneling is required. Rolling rock requirements are cheaper than for railways; ordinary buses can be used. The lighter weight and superior braking power of individual buses as compared with trains can, moreover, permit closer headways. Buses can leave the busway and need not stop on it for loading and unloading, lowering the costs of "stations" and permitting through buses to continue with little loss of speed. Speeds can average 45 miles per hour on the track itself even during peak hours. As a result, capacity of busways per foot-width is as great as can be provided by any other mode. Rates of over 700 buses an hour have been recorded, equivalent to over 3,000 seated passengers per foot-width. Passenger costs are low and can be roughly calculated at around 1½ cents per mile.

As the same vehicle can be used both on the busway and for the collection or distribution routes, busways obviate much of the problem of transfers of rail systems.[10] Because of this feature, busways can be built in discrete parts and extended over time with less dislocation than caused by metros or urban rail. The smaller capacity of

[9] *Large metro systems are also being constructed in Sao Paulo and Seoul.*

[10] *Insofar as the buses are used for distribution services in central districts, the busway capacity will, in practice, be limited by the capacity of the exits in the central district.*

the unit bus as compared with the train unit of railways also permits a more frequent service and less waiting time at stops. A further advantage is that surplus track capacity not required for buses can be used for other vehicles. At peak periods, there may be room only for other collective passenger vehicles such as minibuses and jitneys and essential vehicles such as ambulances and police cars; out of peak periods, it may be possible to admit private automobiles without interfering with bus speeds.

Against these considerable advantages of cost and convenience has to be set the limitation on busways of surface space requirements as compared with a metro—arising out of the technical difficulties of operating buses underground. Ventilation to evacuate fumes may greatly increase the costs of deep tunneling for busways.[11] These factors may preclude bringing busways into the heart of business districts. It may also be difficult, in practice, to exclude other traffic to the extent required for efficient bus operation, in which case the busways will degenerate into all-purpose roads. This danger is particularly great where motorists on highly congested roadways can see apparently underutilized road space on nearby busways.

The Urban Transport System

In the early stages of urban growth, low capacity local roads can provide very cheaply for all kinds of traffic and parking. The various types of vehicles and pedestrians get in each other's way only marginally. Costs of the rights of way are greatly reduced as compared with providing a separate track for each category.

With more traffic, the various uses tend increasingly to conflict. Initially, this conflict can be resolved fairly cheaply by road widening, traffic signals and the like. There may indeed be increasing returns of scale at this stage, the extra costs being proportionately less than the extra capacity created—and this may also apply at a later stage for the rapidly expanding peripheral and local neighborhood road networks.

Further urban growth greatly increases transport requirements as average trip distances lengthen and incomes grow. As noted in the main text, increasing congestion is to be expected due to both higher demand and the increasing costs of expanding central roads. Costs of delays that individual vehicles impose on others can then exceed all other costs attributable to the individual vehicle. Pollution and social disruption increase. Great changes in the mix of transport modes occur as the transport system and land use adapt, with increas-

[11] *The extent of addition to costs is a matter of dispute.*

ing difficulty, to this changing situation. The response is in part conditioned by the perceived costs and benefits involved in the use of various transport modes, and in part by general pricing policies and other influences on urban form.

Fundamental to the selection of appropriate urban transport modes in the conditions of rapid growth of the cities of developing countries are, first, that shortage of space in central areas is rapidly intensifying and land costs are rocketing; and second, that resources are very restricted. The effective central area space can be increased by relatively speedy underground transport needing little surface area. But, as has been noted, the cost of subway construction is very high; only in large cities exceeding two million population with very high densities providing large traffic volumes over many hours a day and favorable tunneling conditions do subways appear a feasible solution. Even then, the costs may only be affordable in the richer developing countries and fares are likely to be too high for the poorer strata of society. Where a subway is feasible, account must be taken of the need to reorient the whole public transport system so that bus routes and subways complement each other.

For the great majority of cities in developing countries and the great majority of their populations, the choice is, and will remain, between either very cheap walking and cycling—providing independence of timing but disadvantages of poor comfort and, for the pedestrians, very limited speed and distance—and the considerably more expensive public or collective transport by bus, surface railway or intermediate public transport. Walking, cycling and regular size buses all provide high capacities in relation to space requirements and low or very low pollution effects. Railways have disadvantages of inflexibility. Capacity of bus routes can be greatly increased by separate rights-of-way, and with the high loadings and volumes of passengers characteristic of the developing countries may be competitive with metros at any traffic volume. Shortages of surface space in central areas however remain a limiting factor.

Minibuses and collective taxis can supplement regular buses both in terms of greater comfort, lower efficient capacity and greater flexibility. However, they take up more road space than regular buses, a disadvantage for central areas. There may, therefore, be a case for encouraging their use for outlying areas but for limiting their use, by charging or other means, on congested trunk bus routes of high passenger density. Against this, however, as they are much more economical than private cars, their obvious potential for substitution for private cars in central areas also needs to be considered.

The advantages and disadvantages of intermediate transport modes in terms of the overall transport system apply *a fortiori* to private automobiles. Comfort, convenience and speed of total trips are so much greater than for other modes as to represent a quantum difference. The independence and liberty of movement they provide represent an emancipation for many owners; hence, the great appeal and tenacity with which their use is defended. However, in terms of road space and total costs to the community their benefits are provided at very high cost. In developing countries, so long as resources available for infrastructure are so limited, the benefits of the few in automobiles using roads *at peak hours* are inevitably accompanied by intensified difficulties for many traveling by public transport, walking or cycling. The conflict could, however, at least in principle be considerably reduced by higher occupancy rates of automobiles.

What may be noted, in conclusion, is that the resource limitations of developing countries appear in any case likely to limit very seriously the possibilities of increasing transport capacity in central areas. The advantages of developing a multicenter urban form are correspondingly increased.

TAXATION OF THE OWNERSHIP AND USE OF AUTOMOBILES

General Taxes and Quotas

It is useful to distinguish charges that relate to vehicle ownership from charges that relate to vehicle use. Charges that relate to ownership, such as import duties, influence the size of the vehicle population, but not the usage of vehicles once bought. Charges related to vehicle usage, such as fuel taxes, primarily affect the use of a vehicle once bought, but only indirectly the total size of the automobile population.

Ownership taxes comprise principally import duties (or purchase taxes where there is local manufacture) on vehicles and parts, and registration and annual license fees. From the fiscal, foreign exchange, and resource economizing points of view, such taxes can be very important. Relatively easy to collect, these taxes have a much higher element of progressivity than in developed countries since private automobile owners generally constitute a small rich class. Progressivity is often increased by higher rates for more luxurious cars or for heavier cars of high horsepower. In many developing countries, such taxes are regarded as a partial substitute for more difficult to collect taxes on income. They often provide a third to a half of the yield of total taxation of automobiles.

From an urban transport point of view, ownership taxes are a somewhat blunt instrument for limiting traffic congestion. By limiting ownership, they limit automobile use not only in congested but also in uncongested conditions where restraint is not required. They do not particularly discourage automobile use at peak periods. Their effect on total automobile population, moreover, is only temporary if incomes continue to rise, unless supported by other measures.[1] If the tax rates vary with horsepower or value, use of small cars may be promoted but this has only a limited effect on requirements for road space.

However, since private automobiles in developing countries are highly concentrated in large urban centers with severely congested conditions, these drawbacks may be outweighed by the advantages of increasing ownership taxes, at least from the relatively low levels prevailing in many developing countries. If congestion and other user

[1] *The effect of ownership taxes on registrations is, in practice, difficult to distinguish from quota restraints since high ownership taxes have tended to coincide with quota restrictions.*

charges are not introduced at appropriate levels, and supported by other measures discussed below, higher ownership taxes and/or quotas may indeed provide the only means of effectively limiting the use of automobiles sufficiently to ensure an efficient public transport service in congested areas. To reduce the disadvantages of ownership taxes, higher annual license fees can be charged in the main urban areas and somewhat less elsewhere though, if the differential is large, evasion occurs via registration in outlying areas.

Import quotas are similar to import taxes in that they reduce the number of imported vehicles and hence raise their effective market price. They also save foreign exchange—which is usually the reason for their introduction. But their disadvantages are many and most countries have relaxed strict quantitative controls after a limited number of years. These disadvantages include the cutting off of automobile supplies for essential urban and nonurban uses. While exceptions can and must, in practice, be made for some of these uses, it becomes increasingly difficult to avoid abuse—while still failing to meet urgent requirements. Where local manufacture of automobiles exists, quantitative import controls may result primarily in protection of inefficient local operations and may lead even to losses in foreign exchange. Moreover, quotas, like ownership taxes, do not affect running costs and provide no special disincentive to automobile use of congested areas.

Usage taxes: Taxes on fuel, tires and lubricants vary primarily with mileage traveled and the weight of the vehicle, and are hence closely related to road use. They normally total half or more of all automobile taxes. As fuel and tires represent only a small fraction of total monetized costs of road transport, and even less if imputed time costs are included, the elasticity of road use to variations in charges for fuel and tires tends to be low. It is indicative that recent increases of 50% in gasoline prices appear to have reduced consumption by less than 10%.

In practice, usage taxes cannot be differentiated to reflect the widely differing social costs incurred by vehicles running on roads varying greatly in basic characteristics, or with time of day. If such taxes were to be raised to levels sufficient to cover the full costs imposed by vehicles using congested city streets, they would be much too high in relation to the very low costs arising out of use of uncongested country or urban highways, and, hence, quite unnecessarily and inefficiently restrict traffic on such roads. It is possible to impose fuel taxes that are higher in congested than in uncongested areas, but any large differences will lead to evasion by uncontrollable movements of fuel from high-tax to low-tax areas.

Congestion Charges

The advantages of charging automobile users directly for the use of congested roads, instead of indirectly by the methods described above, is that action can be more effectively concentrated on the problem with less adverse side effects. Work is now proceeding on two main methods of congestion charging, by daily licenses and by direct metering.

Daily licenses: In this system, vehicles entering or circulating within a congested central area are required to display permits. A recent Caracas study, for example, recommended charges equivalent to $1.32 per day for a private car, $4.40 for a shared taxi and $3.30 for a goods vehicle.[2] The authorized permits to be placed on the vehicle's windshield could be purchased in bulk by road users, either for use on specific dates, or with validation by users themselves for a specific date. The system provides for refunds, so that automobile owners would be charged only for days in which their cars were used in the priced areas. A similar scheme is under consideration for Singapore.[3] In the Caracas scheme, buses were to be exempted; in Singapore, both buses and car pools are to be exempted. The Caracas report estimated benefits from the scheme, in traffic conditions similar to those prevailing in 1971, equivalent to $3.4 million per annum, rising to $68 million per annum by 1980. Gross annual revenues were estimated at over $25 million in 1971 conditions.

Tolls can be regarded as a variation of the daily license system. Tolls can be levied at the entry points to congested areas, the difficulties varying greatly with urban configurations and space available for toll booths. Collection slows traffic and those vehicles that move in the city without passing the entry points are missed.[4] These drawbacks would be overcome if charging points could be spread throughout the congested area and if vehicles could be debited without having to stop. Hence, the interest in automatic metering systems.

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[2] *Alan M. Voorhees and Associates, Inc.,* Caracas Road User Charges: Opportunities and Potentialities, *prepared for the Venezuelan Government with the World Bank's assistance.*

[3] *Singapore Road Transport Action Committee,* A Plan for the Relief of Traffic Congestion in the City.

[4] *A separate case may exist for tolls at entry points to urban expressways to help counter the effect of such facilities on costly urban spread.*

Meters for charging for the use of roads: Meters have been designed to charge directly for the use of roads, whether congested or uncongested. The systems currently being developed are similar to that used for charging for telephone calls. Vehicles passing "pricing points" are identified by sensing equipment. A central computer would count electrical impulses, actuated by passage of the vehicles and generated by electrical cables carrying very low currents laid across the roads, and bill owners accordingly. Tests of electronic identification have proved very satisfactory.[5] It is now proposed to equip hundreds of vehicles using toll roads in New York and San Francisco with these devices, and to give their owners the option of paying tolls on monthly account instead of by the traffic-delaying method of paying cash at the toll gates. Although being developed primarily for revenue collection at present, a great potential exists in using such systems for bus priorities, monitoring changing traffic patterns, identifying stolen vehicles, automatic parking charges, and location of buses and trucks for fleet control. Problems of protecting privacy are involved.

Parking taxes: Parking charges and taxes can serve two purposes besides raising revenues. They can be set to reflect the economic cost of the space used for parking: they can also be used as a proxy for other methods of charging for use of congested urban streets.[6] In the second function, such charges are open to the objection that they discriminate against people who shop, work, and live in city centers, and do nothing to discourage road users who drive through them.

In practice, few cities in developing (or developed) countries levy full charges for parking according to the space and other facilities involved. Yet, in developing countries the case for full economic charging is doubly strong. Economy in the use of scarce transport resources is encouraged. Users belong to the richer segment of the population. Without such charges, the persons parking their vehicles are, in fact, being subsidized and such use is correspondingly encouraged.

The key to economic parking charges is generally in the hands of municipal authorities through control of street parking. When economic charges are made for street parking, it becomes a commercial

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[5] *The systems operated at an accuracy exceeding 98%, with lengthy periods in excess of 99.8%, in tests on buses using the New York Bus Terminal over a period of a year.*

[6] *Complex technical issues are involved including evaluation of alternative uses of road space, effects of vehicles cruising to find parking space, and advantages of curb parking to car owners compared with off-street parking.*

proposition to provide parking off the street—and the private sector can usually be relied upon not to undercharge. In sum, while parking taxes for congestion control may or may not be desirable, there is in most cities a strong case for raising charges to economic levels, first on the street and then off it.

It is also possible to restrict parking by time, as is commonly done at parking meters. Such restrictions, which are only necessary when charges are too low to equate the demand for parking spaces to the supply, are easy to evade and generally have little to commend them over the alternative of restriction by economic parking charges, i.e., charges just high enough to leave a few vacant spaces available at most times for would-be parkers.

Problems in congestion charges: The correct level of congestion charges is difficult to determine. In theory, they should equal the external costs imposed by the use of one vehicle on others, under the conditions prevailing after the imposition of the charge. Such a level would involve at least a doubling of total nontax running costs effectively falling on the automobile.[7] As noted above, the Caracas study indicated an optimal charge of about $1.50 a day. Other estimates go considerably higher. Charges based on rent of valuable central city land might be of the order of $3 a day.

Difficulties of implementation include the tendency to create "minipeaks" of congestion in areas just outside the controlled areas or at times just outside the period during which the charges are levied. Some gradation may be desirable in terms of an outer zone with lighter charges, and a heavily charged inner zone, or a heavily charged full peak period and lower charged surrounding period. The advantages of gradation have to be weighed, however, against the additional complexity.

While the introduction of special charging for use of urban roads during periods of congestion stands out as a high priority among the measures needed, it is not possible to introduce economic charges in the short-term without imposing heavy burdens on many of those who have adapted their living to existing conditions. In general, the rich can pay such charges without serious loss of welfare; indeed, some may experience a net gain as a result of faster trips. It is the poorer of the private vehicle users who will be forced to abandon the use of the automobile, though those poorer still will tend to gain

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[7] *Such a doubling of costs to the owner of running automobiles in congested areas might result, according to various analyses, in a net reduction of about 20% in total vehicle use, a higher reduction in private automobiles being partially offset by an increase in the number of public transport vehicles.*

from increased speeds of public transport. The burden on marginal users can be reduced by increasing the charges in stages over several years and by measures to improve the alternatives to private vehicle operation, particularly public transport by train, bus, minibus or shared taxi. More importantly, perhaps, at higher levels of charging, problems of enforcement may be insuperable in many cities of developing countries.

PROBLEMS OF METHODOLOGY AND MEASUREMENT

Urban transport planning has been carried out in considerable detail for several decades in most large cities of the developed countries and has more recently been extensively adopted in the cities of the developing world. Because of the complexity of an urban transport network with its range of transport modes and changing conditions from one part of the system to another, mathematical modeling and computer technology have been increasingly applied. A wide variety of refinements to the basic models is now available. In general terms, however, the process has consisted firstly in modeling or "simulating" the existing situation, then extrapolating transport requirements into the future and then introducing into the model changes in the transport system capacity as a result of proposed investments to accommodate the increased requirements.

Many sequential steps often involving considerable margins of judgment are involved in preparing conventional urban transport models. The existing or base-year demand, in terms of the number of trips generated for major purposes in different zones of the city, is derived from socioeconomic data on population, density, income, location and car ownership. Trip attractions by zone are similarly estimated with reference to such factors as employment, schools and shopping centers. Distribution of the trips between different zones and times is derived from origin/destination matrices using data on travel time and costs to establish preferences. The split between the various private and public transport modes and assignment of the trips by route are finally estimated by reference to the capacity of the detailed portions, or links, of the transport network and vehicle operating costs in relation to the lengths and timing of the trips. How good a fit is provided to real world conditions is measured by comparisons with traffic counts and household surveys. These are used to adjust the initially assumed relationships so as to "calibrate" the model. Changes in trip generation and attraction for a future or "design" year when the contemplated new investments will have been built are then estimated from changes in population, income, employment, etc. Finally, alternative programs to change the capacity of the transport system are tested to see whether they can cope at satisfactory speeds, and in accordance with estimated modal split and route assignment in the new conditions, with the predicted increases in demand.

For favorable conditions of relatively stable growth in highway requirements and economic structure, the models have provided appreciable assistance in predicting the conditions to be expected as a result of highway investments. In the context of the developing countries, however, these methods have serious limitations both because of weaknesses in the models and because of the more dynamic changes in the cities of the developing world and data inadequacies.

The difficulties stem in part from the interaction between changes in the transport system and the requirements for trips. Facilities provided to meet demand induce additional demand. Short-term effects on the number of trips may be highly important as is frequently apparent when a new major link is introduced such as a new bridge. Longer-term effects on land use, as people and companies adjust their locations to take advantage of changes in transport conditions should also be incorporated. However, no satisfactory way has yet been found to incorporate feedbacks into the models so that the number of trips adjusts automatically to the conditions of transport supply. The models are also weak in simulating traffic behavior under conditions of acute congestion such as are encountered over large areas and long periods in developing countries. The models, in extrapolating one static position to another in a future year, may also be biased towards preservation of highly unbalanced and unsatisfactory conditions. Difficulties also exist in modeling the interactions between different parts of the road network and, in particular, determining necessary speed/flow relationships on minor arterial and local streets. Complex though the grid used customarily is, a more detailed complex of linkages is needed for studying local traffic management schemes such as one-way streets.

Furthermore, the models cannot readily handle major changes in policy such as introduction of congestion charges. Problems arise not only from absence of data establishing the impact of price changes on demand but also from the increasing model complexity. The models are already highly complex and costly to prepare and run as a result of the numerous zones and system links required. Iterative and other processes to introduce additional factors affecting demand, supply and interactions between them, and involving changes in inputs and further reruns, are likely to be prohibitively expensive. Already feedbacks of system supply changes on modal split and trip distribution are proving very costly. Even to evaluate a simple investment plan with existing methodology and computer techniques generally costs well above $500,000 and takes at least two years to become operative. The developing countries may well hesitate on these grounds alone. Attempts to reduce financial and time costs of preparation by borrowing existing models are, in practice, likely to lead to use of models little suited to the particular task or conditions.

For the developing countries, the current conventional urban transport models have further serious limitations due to the rapidity and uncertainty of change. To allow for long time periods needed for technical studies, design, and building of major urban transport investments, the "design year" is often as much as 20 years ahead. Over 20 years, the population and area of a city of a developing country may have more than quadrupled; the urban pattern and the economic and social characteristics of the population will have changed drastically. The growth of income is subject to great unpredictable variation. Alternative estimates of numbers of families able to afford private cars in the design year may, validly, vary by 100% or more. Past data and trends, even if much more accurate than in fact they are, cannot unfortunately provide a reliable guide for future demand conditions either in total or, even less, by city zone. In brief, extrapolation techniques that may be valid for relatively gradual and small changes of urban population, land use and mores cannot be relied upon to yield similar accuracy with the abrupt and large changes encountered in developing countries. There are additional difficulties in evaluating the choice of transport modes. Over 20 years the additions to the transport system in developing country cities will be so large in comparison with the existing system that greater variation in future urban transport patterns is feasible; the existing capacities, which can be measured, are likely to be only a small fraction of the total.

The urban transport conditions in the developing countries, therefore, call for use of somewhat different methodologies. More use should be made of a broad-brush approach to investigate the possibility of considerable changes in the availability of different types of transport facilities in relation to wide alternatives in land use and population characteristics. The desirability of such an outline approach or "strategic planning" as a basis for major changes is, in fact, also becoming increasingly felt in the developed countries.[1] The current emphasis on attempts further to refine computer techniques for extrapolating trends and producing single optimum transport or land use solutions—with all the risks of cumulating errors that

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[1] *As the complexities and costs of existing urban transport computer models effectively limit the testing of more than three or four alternatives, the initial selection of alternatives to test becomes of critical importance.*

this involves—needs to be reexamined. More productive would seem to be the construction of outline scenarios related to minimum objectives and comprising a series of alternative future urban patterns with transport systems corresponding to their density and work-residence location characteristics and closely interrelated with demand.

For the purpose of testing investment alternatives and policy options, trips and speeds by differing modes need to be related to lengths of road and other infrastructure capacity, and with population densities. Observed relationships in a variety of cities can be used to establish such rough relationships and the extent of variations.[2] Social surveys are needed to investigate more thoroughly the extent of latent demand, including particularly households ready to pay for but not serviced by public transport, so as better to establish public transport objectives.

With such an approach, the extent of policy changes and costs of investments involved can be roughly assessed and compared with relative advantages and ease of implementation, substantially narrowing the field before more detailed investigations are undertaken. Since actual developments will, in any case, differ from those assumed, and since what now appears the best choice may cause unforeseen difficulties within very few years, a premium should be placed on keeping options open. Where comparable in other respects, investment alternatives that would be at least reasonable if conditions in fact approximate to a variety of the other scenarios considered should be preferred. Similarly, programs and investments that are sufficiently flexible to be easily adapted to changed conditions deserve special consideration. Road transport systems, for example, should, on these grounds, be generally preferred to fixed track systems, and segregated busways to metros, in view of greater ease of route changes, unless strong cost and location arguments exist favoring the less flexible alternatives.

The long time periods and large changes involved pose further problems in evaluation of costs and benefits of alternative packages of urban transport investments and policies. In urban transport it is difficult to define a "do nothing" situation which would prevail without the proposed investment and against which the situation with the investment can be compared. If the population is doubling or quadrupling, it is inconceivable that no important transport investments will be made in, say, 20 years; in the absence of new and

[2] *See the note on urban transport relationships at the end of this annex.*

sizable investments, the population growth could not occur. Moreover, failure to maintain existing standards of transport availability would result in important changes in urban location which cannot readily be predicted; people seek to minimize the deterioration with which they are faced. In these circumstances, a comparison of benefits from the investment with a "do nothing" situation can be either meaningless or lead to considerable overestimates of both costs and benefits. Insofar as policy changes are involved, it is in any case difficult to apportion the benefits between investment and policy change. It is usually difficult to say what policy changes would have been introduced and what they might have achieved in a "most likely" state without the investment.

A minimum cost approach, in which the least-cost alternative of achieving a stated objective is chosen, may therefore be required. However, if the objectives might be surpassed, a cost-effectiveness approach, in which the additional benefits above the minimum objectives and corresponding additional costs are also taken into account, may be preferable. Even so, difficulties remain in evaluating the additional investments and policies in the transport system which will be carried out or deferred on the basis of alternative projects; for example, what the level of road construction will be under alternatives of a metro or busway project.[3]

A particular problem is involved in determining the value to be placed on time savings. Savings in time usually constitute a large part of calculated benefits. For purposes of estimating the timing of trips and choice of mode, conventional techniques which impute a value for time spent in direct relation to the income of the traveler appear justifiable—provided they are checked against actual behavior. A different set of values will, however, generally be appropriate for determining net time-saving benefits of a project or in the choice between alternative new investments.[4] The highly skewed distribution of income typical of the cities of developing countries can make simple evaluations of benefits of time saving or losses based on in-

[3] *A further difficulty arises when evaluation of separate parts of a package of measures and investments for improving city structure (e.g., transport elements of an area development package) may result in a smaller total of benefits than evaluation of the package as a whole. This may occur where interactions between the parts are important but cannot be calculated.*

[4] *In other words, it is desirable to use shadow prices or valuations in assessing the benefits of alternative solutions to urban transport problems but not in their design. Actual monetary prices or valuations expected to prevail must be used in assessing the physical outcome of projects, levels of ridership, the effects on financial positions, etc. It would therefore be ambiguous to talk of using shadow prices in the design of projects; they are rather to be used to evaluate the results of different designs based on actual prices.*

come levels unsuitable in relation to the basic objectives of urban transport policies. With current methodologies, for example, small time savings for automobile passengers can outweigh much larger time losses imposed on bus passengers. Leisure time of richer travelers is treated as much more important than of poor travelers. Such implicit social value decisions are more in the realm of politicians than of planners or model builders. Time savings and losses must, of course, be calculated. But the time saved or lost should be shown separately by income group. The pricing of the time savings can then be treated as a policy variable by showing the implications of assuming different values for the time of the various groups involved.[5]

Even greater difficulties in evaluation of alternatives, however, arise from the importance of the "nonmeasurable" repercussions of urban transport projects. Just because they are difficult or impossible to measure in monetary terms, the impacts of transport projects on the physical and social environment tend to be unduly neglected in formal evaluations. It is, of course, necessary to measure and compare economic efficiency insofar as possible. But lack of similar monetary measures for say deterioration or improvement of neighborhood living conditions does not make such aspects any less important. Sometimes, different alternatives have much the same impacts in these respects; for example, two different road alignments may have quite similar social impacts. If in such cases the impact appears on balance favorable, it may be reasonable to ignore these aspects of the evaluation. When the impacts differ considerably, for example, between road and subway alternatives or in comparisons with alternative investments in other sectors, this is not justifiable. Often, it should be possible to provide information in physical units, for pollution and noise levels; for example, even where monetary values are not available. Accordingly, "balance sheets" indicating not only monetary costs and benefits but the degree to which physical objectives are attained should be included in the evaluation.[6]

The desirability of developing, implicitly if not explicitly, a set of minimum objectives, the limitations of the methodology, and the importance of taking "nonmeasurables" into account in the evalua-

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[5]*Other problems of evaluating time savings arise from the fact that persons tend to have "travel time budgets." Their own valuation tends to rise the greater the amount of travel time in the day already preempted. Conversely, higher speeds may not save total daily travel time but rather induce more or longer trips. This phenomenon is not taken into account in current models where the number of trips is taken as a fixed total.*

[6]*Similar difficulties arise in determining the appropriate social rate of discount particularly where provision is being made for future generations.*

tion, all point to the need for urban transport planners to secure the cooperation of the decision makers at an early stage in development of programs and in subsequent stages. Political as well as technical decisions must be involved.

It should be noted finally that it is generally not possible, because of the multitude of interlinkages involved and other influences that intervene, to measure directly the effects of urban transport investment on urban productivity or efficiency in any general sense. The alternative of measuring cost reductions can be applied in relation to commercial traffic and for operating costs of other road transport. For other aspects of costs of time and discomfort and the impact on urban patterns, the problems are much greater.

The difficulties involved in evaluating urban transport projects and policies are, as indicated, formidable. Conventional cost/benefit analysis needs to be supplemented by many further considerations for a fully adequate assessment of the balance of benefits. Fortunately, however, even minimal evaluation of benefits and a conservative evaluation of costs will in most practical cases provide a sufficiently pronounced balance to indicate the desirability or otherwise of urban transport projects. While, therefore, it is extremely difficult, and probably impossible, to be sure of achieving optimal urban transport investments, it is generally quite feasible to be reasonably sure of attaining major, though inevitably suboptimal, improvements.

Note on Urban Transport Relationships

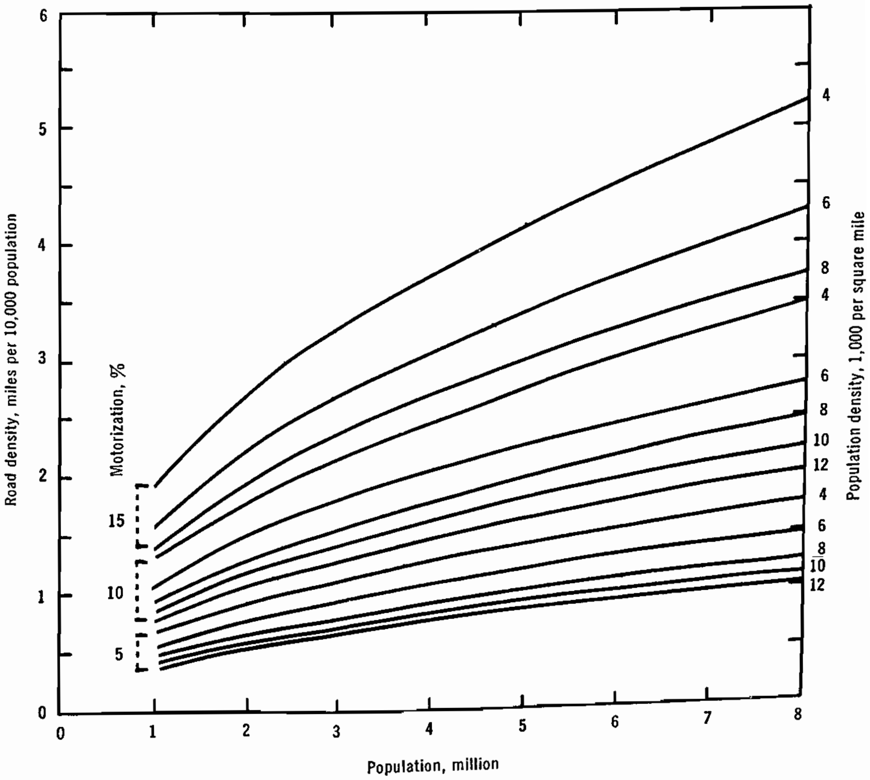
An initial study has been made based on data collected from a number of cities of the effect of different levels of motorization and population densities on road requirements, speed and number of motorized trips for cities of various sizes.[7] The available data are still too few to permit definitive conclusions on the relationships, but there are indications of sufficient consistency in the results to warrant further development of the methodology. It should also be noted that the data reflect actual conditions, not what might be achieved by more purposeful measures to develop economical urban patterns such as would, for instance, reduce commuting distances.

With the reservation that results from the preliminary investigations should be regarded as illustrative only, the following deductions from the data may be noted. Some of the relationships are indicated in the diagram.

[7] *Y. Zahavi,* Travel Characteristics in Developing Countries, *a Bank Staff Working Paper.*

Arterial Road Density by Motorization and Population Density vs. City Size

(For a vehicle trip rate averaging five trips per day)



Average Trip Distance

When a city grows in population and size, average trip distances lengthen. The analysis indicates that for a given population density trip distances increase roughly in proportion to the square root of the radius of the city. For instance, growth in city population, say from 1 to 2, 4 and 8 million, with population density remaining constant, may be expected to increase average trip distance by roughly 20%, 40% and 65%, respectively, from the initial level.

Decreasing population density tends to increase the trip distance, since a lower density implies a larger area for the same population. Thus, if two cities have the same population, say 2 million, but one has a population density of 12,000 people per square mile, while the other has a density of 6,000, the average trip distance in the latter case will be found to be longer by about 20% than in the first case.

When cities grow in population, population densities tend after a time to decrease. Thus, the adverse effects of increase in population and decrease in density tend to cumulate. For instance, if a city grows from 2 to 4 million while its population density decreases from 10,000 to 8,000, the average trip distance may be expected to increase by about 25%. If an average vehicle in the first case makes five trips during its daily travel time of 1.2 hours at a speed of 12.5 miles per hour, the same vehicle will probably have to travel at a speed of 16.5 miles per hour to make the same number of trips in the second case. Furthermore, the same vehicle in a city of 8 million with a population density of 6,000 will need a speed of about 20 miles per hour to achieve the same trip rate. This explains why travel speeds have to increase in expanding cities if vehicle trip rates are to be maintained within the same travel time per vehicle per day.

The Effect of Speed on the Need for More Roads

For a given flow of vehicles, higher speeds require more (and/or better) roads. By considering the relationship between flow, speed and arterial roads for the previous example, it can be shown that while the ratio of road length to population in a city of 1 million is likely to be about 0.42 miles per 10,000 people for a population density of 10,000 and a motorization level of 5 cars per 100 people, the ratio of road length per 10,000 people is likely to increase to about 1.48 in a city with 8 million and population density of 6,000 per square mile, even if the level of motorization remains the same. Some 3.5 times more roads per inhabitant will be required to keep the same level of mobility at the same level of motorization. This appears to be one explanation of the increasing difficulties in providing adequate mobility in larger cities, particularly those that expand rapidly.

Very high densities of arterial roads are impractical since roads will become too closely spaced to allow efficient land use development. Furthermore, traffic speeds cannot be increased above, say 30 miles per hour, by the addition of further arterials because of operational and safety constraints. There is therefore a practical limit to the extent to which additional arterial roads can increase speeds. After a certain city size (depending on population density and motorization level), it becomes necessary to use high-speed roads such as expressways and/or reserved track for railways or busways to maintain the same level of mobility in an expanding city.

Effect of Motorization

When the factor of motorization is added, travel conditions are aggravated even further since more cars per hundred population will require more roads if speeds are to be maintained within the same travel period.

Thus, under the conditions of this example, if motorization levels were to increase from 5 to 10 cars per 100 inhabitants, the road density would have to be increased from 0.42 to 2.49, namely a sixfold increase.

Conclusions

Heavy investments in urban infrastructure can be deferred if closer attention is given to population density, land use arrangements, mass transport and level of motorization. Highly compact cities with rapid public transport will not only need less motorized travel by cars but will also discourage a rapid increase in motorization. If, on the other hand, a city is allowed to grow freely in both size and motorization, the transportation burden on its inhabitants is likely to become prohibitively high, resulting in congestion and self-strangulation.

In developing countries, where all the factors such as population area and motorization increases at a rapid pace, planners should be aware of the probable impacts of these factors on the physical, economical and social development of the cities. Policies and plans should be reevaluated in the light of the factors illustrated above.

World Bank Offices

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