A CHARACTERISTICS APPROACH TO URBAN PASSENGER TRANSPORT EVALUATION AND PLANNING

by
Charles L. Wright
Brazilian Transportation Planning Agency (GEIPOT) and University of Brasília
SQS 309, H, 105
70.362 Brasília-DF
BRAZIL

1. INTRODUCTION

Rapid population growth and rural-urban migration are doubling the populations of many cities in developing countries in as little as 10-15 years, requiring major changes in their transport systems. The provision, maintenance and operation of these systems have major impacts on municipal finances, energy consumption, pollution, use of urban space, passenger travel times and the general welfare of urban residents. The criteria used for selecting, financing and pricing major transport projects, as well as orienting day-to-day traffic engineering practices, will have a highly influential role in shaping the future human and economic urban transport environment.

Latin American cities, from which the examples in this paper are taken, have an uninspiring record. Local authorities often approve major transport projects without any formal economic evaluation, while international lending agencies normally require a single-valued financial criterion, such as the benefit/cost ratio[1]. The results have been heavy investments in expressways, elevated highways and similar auto-oriented strategies, coupled in some instances with expensive metros. These have often placed intolerable burdens on municipal finances, distributed costs and benefits regressively among taxpayers and transport users, and contributed to choatic and deteriorating urban environments.

In consequence, a growing number of researchers and planners in Brazil, Venezuela and other countries have opted for various types of cost--effectiveness analysis or multicriteria techniques. They have often been successful in making major improvements in urban transportation with very limited financial resources. For example, a few years ago in Maceió (a medium sized city on Brazil's Northeastern coast), final engineering studies had been prepared for a complex set of expressways and overpasses. The mayor became worried that those construction projects would disfigure and bankrupt the city without solving the problem of congestion in the decaying central business district (CBD). An agreement with GEIPOT's urban transport group resulted in shelving those plans in favor of improvements in simple traffic engineering measures. Those changes quickly improved bus and delivery-truck circulation, and allowed only short-term auto parking in the CBD. The only construction undertaken involved larger sidewalks, a pedestrian mall and a drainage channel to avoid rain-provoked flooding. The traffic problem has been solved for the near future, and the CBD has been revived.

---

[1] The B/C ratio is considered representative of the class of single-valued monetary criteria, including the internal rate of return (IRR) and net present value (NPV).

Some economists[2], however, have criticized cost-effectiveness and multicriteria techniques for neglecting economic theory, using "ad hoc" reasoning, subjectively assigning weights to the criteria used, "equating chalk with cheese", confusing planners and failing to provide a standard for allocating funds among different sectors of the economy such as the interest rate embedded in the B/C ratio. Lending agencies often favor the B/C criterion with the business-like argument that a project must be "economically sound" and "able to pay for itself".

If the B/C advocates are correct, we are left with the unlikely hypothesis that good theory tends to produce bad results, while poor theory - or none at all - tends do produce good evaluation and planning. This contradiction disappears, however, if Samuelson is correct in stating that there is no conflict between theory and practice: if bad results appear, it is because the theory is incorrect. The favorable results of multicriteria techniques conversely imply that they are implicitly based on more adequate theory.

The objectives of this paper are: (1) to show that there is no theoretical justification for the use of B/C analysis in the evaluation of Latin American urban transportation projects; (2) to develop an alternative theory for multicriteria techniques based on objective transport characteristics and Lancaster's modern consumer theory; and (3) to indicate the changes these will imply regarding the future transport and urban environment in Latin America.

2. TRANSPORT PLANNING AND EVALUATION: A CRITIQUE OF THE B/C APPROACH

As a general principle embodied in theories of government planning such as the Planning, Programming and Budgeting System (PPBS), project evaluation should be an integral part of overall transportation, urban and economic planning. The projects selected should be coherent with overall socio-economic goals, grow out of a systematic examination of all relevant alternatives, and be financially viable in the face of local, state and national budget constraints. In practice, however, B/C analysis tends to be used to justify isolated projects without examining any alternative aside from the "status quo"[3]. Highway engineers lobby for expressways and elevated highways, national and foreign consulting firms would like to sell their services and systems, the mayor wants an expressway linking one of his constituencies to the CBD, or a metro to make Rio or Bogotá as modern as Paris. As will become clear in a moment, the beauty of the B/C ratio is that all those individuals and groups can use it to demonstrate the "soundness" of their favorite projects.

One can of course argue that these are merely examples of incorrect use of B/C analysis, and that the ratios should be calculated for alternative projects and the best one(s) selected. The counterargument is that the ratio offers no guide as to what project or combination of projects should be evaluated in the first place since, by its very (pre-Lancasterian) nature, it focuses on projects and their monetary aspects rather than on the relevant characteristics of transport modes and urban environments. This is a crucial theme we shall return to; for now we note that the B/C ratio is normally used in isolation because it does not lend itself to use in a systemic

---

[2] What follows is a summary of verbal and written comments of the author's discussions with economists on this subject in recent years, and of the opinions in Harberger's article.

[3] See, for example, Thomson's review of metro projects in Latin America.

process of evaluation, such as PPBS or the approach described by Manheim (Chapt.9).

Even on the isolated project level, the B/C ratio is invalidated on a number of points. This can best be seen by examining the components of the ratio and the respective assumptions on which they are based. The ratio is simply:

$$B/C = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+i)^t}}$$

where T is the life of the project, B_t and C_t are the benefits and costs in year t, and i is the interest rate (also called the opportunity cost, social discount rate, etc.). Establishing the i value is at best guesswork, and the same often applies to T. Either may be established arbitrarily by lenders or government agencies[4]. The non-monetary nature of returns to other public expenditures also make i a fickle master for resource allocation among sectors.

A) The ratio includes only those benefits and costs which can be quantified in monetary terms. It cannot measure most of the benefits and a good share of the costs of urban transport projects, since they are not monetary, but physical or psychological. There are no defensible monetary units for air pollution, noise, land use, travel time, accidents, deaths and consumption of energy from different sources, but all can be objectively measured in parts per million, decibels, square meters, or other physical units. The degree of passenger discomfort and effects of visual pollution cannot be so easily measured, but different modes and projects can be roughly ordered regarding their degree of acceptability. Instead of dealing with physical and psychological measures, the B/C analyst calculates "shadow prices" for energy costs, values travel time at the per minute salary rate of passengers, and imputes values for people's lives based on their discounted future earnings. (This last implies a zero value for a housewife's life, a near-zero value for children's lives, and a high value for prosperous automobile owners' lives - a senseless process economists should abandon altogether). In short, it is B/C analysis, not the alternatives, which "equate chalk with cheese" by using a monetary yardstick to measure non-monetary phenomena.

In practice, the bulk of most transport project benefits in B/C analysis are the imputed values of travel time saved. Although such travel time reductions probably have no monetary opportunity costs at the margin, savings of minutes and seconds to upper income highway and metro users furnish a sufficiently elastic measure of benefits to give even outlandish projects a favorable B/C ratio, provided, in some cases, that important costs are ignored.

The most important costs of expressways and metros may well be the lost opportunity to benefit many more transit users with the same funds, as will become apparent in the next section. But there is also a tendency to underestimate construction and equipment costs and to be overly optimistic regarding total construction time. The real cost of subway cars in Santiago,

---

[4] The internal rate of return does not avoid the arbitrary i, since a minimum rate must be established to approve projects, which is equivalent to setting i in the B/C ratio. See note 1.

for example, was four times that estimated in the feasibility study and could be purchased only in the foreign consulting firm's country (Thomson). Metro studies also tend to ignore the costs imposed by traffic disruptions which their construction entails during a decade or so. Studies of elevated highways conveniently ignore their traumatic effects on the quality of urban life. One particularly grotesque example is the Costa e Silva elevated highway in São Paulo, which winds through heavily populated areas at little more than an arm's reach of the windows of residential and commercial buildings. Noise levels are so intolerable that the elevated has to be closed from midnight to 6 a.m. so that nearby residents can get a few hours sleep. Urban traffic is responsible for 50% of the air pollution in cities such as Washington, D.C. (Stone), and probably for comparable amounts in most major Latin American cities.

Most isolated B/C evaluations conveniently ignore such negative characteristics. Mishan (Chapter 24) likens this to making a horse and rabbit stew on a strict one-to-one basis: it does not matter how well one measures the rabbit (the monetary costs and benefits of a transport project), since the flavor will be dominated by the horse (externalities and non-monetary factors). On purely monetary grounds, furthermore, B/C analysis can also be shown to be an invalid means of evaluating transport projects in Latin America. As Mishan (Chapters 58 and 59) points out, its theoretical foundation derives from the concept of Paretian optimality. Under this standard, the only projects which can be said to improve public welfare without resorting to interpersonal value judgements are those which leave at least one person better off without leaving anyone worse off. But since transport projects are not financed exclusively from user charges, non-users pay for others' benefits, violating the Paretian standard. Mishan suggests circumventing this difficulty through the theoretical compensation test: if the winners could compensate the losers from the project's benefits and still be better off as a group, a net social surplus would be generated (B/C > 1). However, since no such compensation can be made in urban transport projects. Due to high transactions costs, the hypothetical test has no bridge to reality. Harberger's suggestion (p.785) that costs and benefits be summed without regard to whom they occur amounts to the assumption that the existing distribution of income is optimal, and that the marginal value of income is the same for different income groups[5]. Such hypotheses might be tolerable in countries with low inequality and little absolute poverty, but must be rejected in Latin America.

The following data, for example, show that the richest 20% of the population of Latin America countries earn about 20 times more than the poorest 20%. The high degree of inequality explains the prevalence of absolute poverty despite reasonable per capita income levels (Wright, 1978).

[5] Indeed, since the very prices which are considered in B/C analysis (even if free of taxes and subsidies) are determined by the existing distribution of preferences, resources and income, their use also assumes the existing distribution of income and wealth is optimal (Bromley). Harberger's opinion that economists have no expertise in analyzing income--distributional questions ignores their unique tools for quantifying distributions and analyzing the distributional effects of economic policies. Many great economists from Smith and Ricardo to the present have considered distribution a central problem in economic analysis.

COUNTRY	GNP/Cap. US$ 1975	% OF TOTAL INCOME	
		POOREST 20%	RICHEST 20%
LATIN AMERICA			
Ecuador	314	2.5	73.5
Brazil	456	3.1	62.2
Uruguay	721	4.3	47.4
Peru	546	1.5	60.0
Honduras	301	2.0	65.0
Mexico	697	4.0	64.0
Panama	773	2.9	59.3
Chile	904	4.5	56.8
OTHER COUNTRIES			
Korea	269	7.0	45.0
Taiwan	366	7.8	41.4
Yugoslavia	602	6.5	41.5
E.Germany	2.046	10.4	30.7
U.S.A.	5.244	6.7	38.8
W.Germany	3.209	5.9	45.6
United Kingdom	2.414	6.0	39.2
France	2.303	1.9	53.7
Japan	1.713	4.6	43.8

SOURCE: Ahluwalia, p. 340-1.

At present, a transport project which saved a Brazilian minimum wage earner US$10 per month would save one sixth of his income, versus less than 1% of the income of someone in the upper 20% of the income distribution. In such circumstances, many workers spend up to 30% of their net incomes on buses to get to work and back. Clearly, the marginal value of income is worth much more at the low end of the earnings scale, and distributional questions must therefore be taken into account. Expressways and metros serve the higher income levels in Latin America (Thomson) and are financed out of public funds drawn disproportionately from low income groups and regions. Surface rail, bus and trolleybus projects, on the other hand, favor lower income groups and imply lower levels of public expenditures.

The public outlay aspect also has been neglected by the isolated monetary criterion approach. Far from assuring that a project is "economically sound" or "will pay for itself", a favorable B/C ratio is unrelated to returns to public coffers. Neither Rio nor São Paulo, Brazil's two richest cities, were able to pay the loans for their metros, forcing the federal government to bail them out. In 1979, however, the Ministry of Transportation announced that its priorities would be increased fuel efficiency per dollar spent, better transport for low income populations, and austerity. These guidelines have meant no new metros, along with a drying up of federal funds to extend existing ones or to build elevated highways, regardless of their B/C ratios.

The final criticism of B/C analysis explains why its use has no necessary relation to systemic evaluation or even to sensible policy guidelines: it is based on pre-Lancasterian utility theory. In that theory, a consumer's utility is a function of the goods and services he consumes:

$$U_i = f(X_{i1}, X_{i2}, \ldots, X_{in})$$

where U_i = consumer i's utility, and X_{ij} = jth good or service consumed by i. Other assumptions not already commented on include:

a) Consumers always prefer more of X_j, so that $U(nX_{ij}) > (mX_{ij})$ if $n>m$;
b) consumption itself is costless;
c) consumers' tastes are given and stable;
d) consumers have perfect information.

Lancaster's contribution demonstrated that utility is in fact a function of the characteristics of goods and services, that any product or service normally has a number of characteristics associated with it, and that any given characteristic can be obtained from a variety of sources. The erroneous traditional assumption explains the B/C focus on specific "goods" (projects), rather than on the best way to obtain a desirable set of transport characteristics. The urban environment is similarly neglected, since consumer i's utility function includes only those goods and services which he himself consumes, omitting the effects of the production and consumption of other economic agents on his welfare, via congestion and pollution, among other factors.

Assumptions (a)-(d) of traditional consumer theory, although not analyzed by Lancaster, are likewise invalid in the case of urban transportation. Most users want a better package of transport characteristics and would probably prefer to consume fewer transport services (other things constant). The consumption of transport services has psychological costs: transit users in Latin America often spend several hours per day in hot, crowded buses and trains, with significant negative effects on their well-being and productivity. Consumer's tastes change with economic and other circumstances: corporations spend a good deal of resources to shape preferences, especially if they are selling automobiles, as Galbraith demonstrated some years back. And consumers have highly imperfect information regarding transport characteristics and alternatives, as do many decision makers. Public education in these matters may in fact be one of the most important variables in transport planning.

3. THE CHARACTERISTICS APPROACH

The preceding discussion revealed that project evaluation should be part of a coherent process of transportation planning. Modern utility theory and the existence of externalities imply that the correct starting point in this analysis is the following utility function for the typical transportation user, a urban resident or taxpayer i:

$$U_i = f(C_{i1}, C_{i2}, \ldots, C_{in})$$

where C_{ij} is the jth characteristics of a transport policy which effects citizen i. These characteristics may be the result of his own consumption of transportation services or, as in the case of pollution and congestion, the result of consumption by other individuals and firms. The new function therefore incorporates externalities in a simple and direct way.

This utility function now applies to transportation planning in a logical manner. The planning process consists of a systematic search for the set of characteristics which maximizes the utility of transport users and urban residents, subject to the relevant constraints on local finances. This implies that no project can be evaluated in isolation. No longer can engineers work in isolation for months or years to produce a final, immutable project, leaving the economist to calculate its B/C ratio and decision makers with only the choice of accepting or rejecting the final product. Instead, planning begins with the question of which transport and environmental characteristics are most deficient.

At this point it must be recognized that planning and evaluation are not value-free. As Myrdal shows, the nearest an analyst can come to being objective is to state his value judgements explicitly and to conduct his work in accordance with them, As noted, the strict Paretian criterion cannot apply to transport projects. In practice, some benefit while others pay, and the hypothetical compensation test historically disguised the fact that the poor in Latin America were paying for projects which benefited the well-to-do. A modified Paretian criterion is here suggested which is in line with the general principle of democratic government enshrined in many constitutions: majority rule with protection for minorities. This amounts to the old utilitarian principle of "the greatest good for the greatest number", with the addendum that this should not cause undue hardship for the rest of the population.

Once the problem has been defined in terms of the characteristics to be altered, with the first priority given to low income populations, planners must systematically examine the alternative means of furnishing those characteristics. Initially this will entail discussion, at a very gereral level, of appropriate combinations of policies, modes and traffic engineering measures for providing low income travelers with a better combination of transport characteristics.

The discussion will result in a general strategy for achieving the desired characteristics set. The main impacts on different income groups should now be examined to furnish some indication of the validity and effectiveness of the proposed strategy, which sould be modified if found deficient in any important aspect. When the strategy is found coherent, work will focus on the alternative specific measures for providing the characteristics at reasonable levels of expenditure. As specific proposals emerge, they will be checked against the goals, strategy and financial constraints, and will be quantified in an increasingly precise manner. The goals, strategy and proposals will be reexamined and modified as the need occurs, in an iterative fashion. This process is summarized in Figure 1.

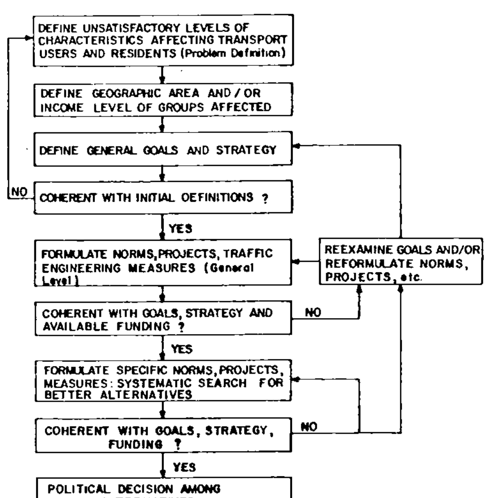

Figure 1 - THE CHARACTERISTICS APPROACH TO URBAN TRANSPORT PLANNING AND EVALUATION.

The ultimate product will be a series of alternatives for obtaining the new transportation and urban characteristics set. There will be no unique solution although, as we shall see presently, certain strategies tend to dominate. Any of the alternatives so produced will be good in the sense that it furnishes some desirable characteristics. In most cases, there will be a few measures which can be easily undertaken in the short run, while others require more time and funds. These can usually be merged into a coherent transportation plan covering several years. Some examples are given in latter paragraphs. At this point it is necessary to become more explicit regarding the characteristics themselves.

Table 1 presents 14 characteristics associated with eleven transport modes[6], classified in relation to each other as superior (S), intermediate (I) and poor (P). These qualitative rankings are derived in most cases from objective economic or engineering data such as that in Table 2 or that given in the manual of the Institute of Traffic Engineering. The "psychological" variables, such as "comfort", represent a consensus developed over the years by the author and his students regarding Brazilian experiences with these modes (where applicable). Most of the characteristics are self-explanatory. "Psycological and social aspects" is a variable described in more detail by Stone, and refers to the freedom that users of a given mode have to choose their traveling companions, smoke or be free of smoke, listen to Mozart, acid rock or ride in silence, and so on. The "good for health" variable refers to the degree of beneficial exercise or negative tension associated with the mode. The "individual modes" (walking, cycling, cars and taxis) rate well in regard to psychological and social aspects, comfort, frequency and flexibility. Walking and cycling are the only healthful modes, although well--run public transportation permits relaxation. If poorly run and overcrowded, it is even worse than automobiles as a source of stress. Walking gives lowest door-to-door origin-destination time up to 0.4 km, bicycles from 0.4 to 1.5 km, and cars from there on. The bicycle outspeeds public transportation up to some 5 km. Cars and taxis are the only modes which provide convenience for shoppers' packages; although bicycles can be adapted to transport up to 100 kg.

Walking and cycling score highly in all categories except personal injuries, comfort, speed on longer trips and carrying of parcels. The wide variance for the personal injury item indicates that the degree of safety is not an inherent characteristic of these modes. The degree of danger is determined by the design of walkways, bikeways and intersections with motorized traffic, enforcement of safety regulations and similar factors. Motorized vehicular traffic is responsible for virtually all deaths and injuries to pedestrians and cyclists. Pedestrian accidents account for around one-fourth of all traffic fatalities in the United States and perhaps half of traffic fatalities in many Latin American cities. Vehicle accident figures are several times higher in countries such as Brazil than in the U.S.A. or Europe (DETRAN-DF). The same type of variation (superior-to-poor, superior--to-intermediate, or intermediate-to-poor) is seen in Table 1 for the diesel bus, electric bus, streetcars and trains. All these modes have a considerable potential with regard to comfort, punctuality, frequency and low cost to users, but their neglect in most of Latin America has often left them in a severely deteriorated condition, with overcrowded cars and undependable service (Moisés and Martinez-Alier).

---

[6] Three modes which are important in many Latin American cities have been omitted to simplify the table: animal-drawn vehicles, boats and trucks.

TABLE 1 - CHARACTERISTICS OF TRANSPORT MODES

MODE CHARACTERISTIC	WALKING	CYCLING	MOTOR CYCLE OR SCOOTER	TRACTOR* SHUTTLE	PRIVATE CAR	TAXI	BUS	TROLLEY BUS	STREET-CAR	TRAIN (SURFACE OR ELEVATED)	METRO
1. Low energy/pass.km	S	S	S-I	S	P	P	S	S	S	S	S
2. Low pollution											
(a) air (per pass.km)	S	S	S-I	S-I	P	P	S-I	S	S	S	S
(b) noise (per pass.km)	S	S	P	S-I	P	P	P	S	I	I-P	S
(c) visual	S	S	S	S	S-P	S-P	S-P	P	S-P	I-P	S
3. Low personal injury/pass.km	S-P	I-P	P	S-I	P	P	S-I	S-I	S-I	S	S
4. Capacity/area occupied	S	S	S-I	S-P	P	P	S	S	S	S	S
5. Psych. + social aspects	S	S	I-P	P	S	I	P	P	P	P	P
6. Good for Health	S	S	P	I-P	P	P	I-P	I-P	I-P	I-P	I-P
7. Comfort	S-P	S-P	S-P	I	S	S-I	I-P	I	I-P	S-P	S-P
8. Punctuality	S	S	S	S-P	S	S-P	I-P	I-P	P	S-P	S
9. Frequency	S	S	S	S-P	S	S-P	S-P	S-P	P	S-P	S
10. Low cost to users	S	S	S	S-I	P	P	I	S-I	S-I	S-I	S-I
11. Flexibility	S	S	S	I-P	S	S	S-I	I-P	P	P	P
12. Least Time O-D											
(a) short distance	S	S	S	S-P	I	P	P	P	P	P	P
(b) medium distance	P	I	S	S-P	S-I	S-I	S-I	S-I	S-I	I-P	I-P
(c) long distance	P	P	S-P	P	S-I	S-I	S-I	S-I	S-I	S-I	S-I
13. Low Cost To Public Coffers	S	S	S	I	I-P	I-P	S-I	S-P	I-P	I-P	P
14. Carry Packages Conveniently	I-P	I-P	I-P	I-P	S	S	I-P	I-P	I-P	I-P	I-P

Notes: S = Superior; I= Intermediate; P= Poor.

* Tractor Shuttle is formed by a series of rubber wheeled cars pulled by a farm tractor or similar power source. Low speed, easy entrance and exit and driver's vision permit its use on pedestrian malls and in other congested areas.

TABLE 2 - CAPACITIES AND COSTS OF PASSENGER TRANSPORT FOR SELECTED MODES IN LESS DEVELOPED COUNTRIES

	SPEED (km/h)	CAPACITY[a] (pass/m per hour)	COST (U.S. cents/pass.km)			
			CONSTRUCTION	MAINTENANCE	VEHICLE OPERATION	TOTAL
SIDEWALK (1.22m wide)	3.4	3,609	c	c	c	c
BIKEWAY (1.22m wide)[b]	12.9	1,476	c	0.2	c	0.2
URBAN STREET W/MIXED TRAFFIC, 7.3 m WIDE[b]						
CAR OR TAXI WITH 1.5 OC. FACTOR	24.2 16.1	143 251	1.7 1.0	0.2 0.2	5.4 6.0	7.2 7.2
CAR OR TAXI WITH 4 PASSENGERS	19.3 13.8	394 656	0.6 0.4	0.1 0.1	2.1 2.4	2.8 2.8
MICROBUS WITH 10 PASSENGERS	16.1 12.1	492 820	0.5 0.3	0.1 0.1	1.2 1.5	1.8 1.9
BUS WITH 30 PASSENGERS	13.8 10.8	984 1,640	0.2 0.1	c c	1.1 1.2	1.3 1.4
EXPRESSWAY						
CAR OR TAXI WITH 1.5 OC. FACTOR	64.4	886	2.1	0.2	4.6	6.8
CAR OR TAXI WITH 4 PASSENGERS	64.4	2,362	0.7	0.1	1.7	2.5
MICROBUS WITH 10 PASSENGERS	64.4	3,937	0.5	0.1	1.1	1.6
8US WITH 40 PASSENGERS	64.4	6,562	0.2	c	0.7	0.9
SURFACE RAIL (22,500 pass/h)	48.3	5,577	0.6	0.4	0.4	1.4
METRO (22,500 pass/h)	33.8	5,577	1.6[d]	0.4	0.4	2.4[d]

SOURCE: Figures derived from data in World Bank (1975), p. 74.

[a]Persons per hour per meter of width of passageway.

[b]Capacity per meter increases roughly one-third for most motor vehicles when street width is 13.4m. A wider bikeway than the mere 1.22m path considered would presumably have an equal or greater effect.

[c]Negligible (value less than 0.05 cent).

[d]These costs may be considerably higher for many cities.

Thus, one important conclusion is that many important "psychological" characteristics are not inherent to the modes themselves, but are determined by public investiment and policy decisions. Where resources are directed to automobiles and metros, the characteristics of other modes will deteriorate even though they transport more passengers. Measures such as implanting trolley buses and exclusive bus lanes can reverse this tendency. Brazil has had some success with all of these policies since setting forth its new guidelines in 1979, despite severe budget limitations (e.g., electric buses in Ribeirão Preto, bus lanes in several cities and the new "Padron" buses).

A second conclusion is that walking and cycling score so highly with respect to most characteristics that they need to be taken quite seriously in transport planning. Table 2 reveals that these modes have transport capacities among the highest of any mode in congested urban centers. They are also the most efficient in terms of energy used per passenger-km. In New York, walking accounts for 24 to 70% of all passenger-km between 6 am and 9 pm (Institute of Traffic Engineers, p.63), while a forthcoming GEIPOT study shows that in many medium-sized Brazilian cities more than half of trips over 0.5 km are made on foot. As Mumford foresaw decades ago, "no city can solve its transportation problem if it neglects the greatest self-propelling vehicle of all: the pedestrian" (p. 119). Bicycles also offer a vast potential for mass transportation and are so used in a few countries as diverse as Holland and China, along with a few cities in Brazil. However, to promote them as safe and rapid modes of transportation, planners must isolate pedestrians and cyclists from motor vehicles by reserving exclusive rights-of-way, safety islands and secure crossings. Duarte argues that strict physical separation of pedestrians and cyclists from motor vehicles at ground level is feasible only in rural areas, certain residential sectors and new towns where the physical layout permits such segregation. In many urban areas, segregation will require elevated passageways to avoid contact at intersections and dangerous proximity or encroachment of sidewalks and bikeways by cars. This is in fact the solution used in the new Dutch town of Lelystad, and a Canadian diplomat in Brasília recently informed me that a Canadian firm is trying to market elevated bikeways in the U.S.A. Duarte, however, suggests something beyond the Lelystad pedestrian-cyclist bridges: the elevated bikeway should be made of light metalic structure, covered to protect the cyclist from inclement weather, have attractive design and possess lateral railing high enough to eliminate any possibility of falls. These ideas would so increase cycling's set of positive characteristics that it would become the superior mode for most short and medium distance trips. There are no serious technical difficulties , and a one-time investment in elevated bikeways with minimal maintenance costs would of course be far less expensive than building metros or the permanent drain of burning petroleum products in cars and buses or subsidizing public transit. However, it requires inverting the traditional assumption that governments should invest the lion's share of their funds on motorized transport and magnanimously donate leftover crumbs to the charitable cause of cyclists and pedestrians. In Duarte's proposal, these travelers, as the most efficient users of space and energy, are treated as Very Important Persons, rather than forced to ride in rain or snow and be splashed, delayed or endangered by motor vehicles.

Thirdly, the tables show that certain variables tend to move together within the two motor classes of cars and taxis, on one side, and buses, trolley buses and rail transport, on the other. The two key variables here are capacity (efficiency in moving passengers within limited urban space) and energy use. Cars and taxis are the most energy-inefficient of all transport modes and require the most urban space to transport a given number of people. By using the most fuel per passenger-km, they also cause the most air pollution. This inefficiency in the use of fuel and space is inherent, since it can only be reduced by drastically changing the automobile's characteristics, i.e., converting it into a three-wheeled motorbike and operating it as a small bus with four or more passengers. Conversely, buses and rails have inherent advantages over private motor transport with respect to the same variables: they use less space, less fuel and cause less air pollution to transport the same number of passengers. The space variable would favor them even more if parking space in congested areas were taken into account.

Fourthly, the levels of many characteristics of the various public vehicle modes are seen to be quite similar. Buses with exclusive lanes, if operated in "waves" and equipped with appropriate entrances and exits, carry the same number of people per area occupied as metros (metros can of course carry more in rare, bone-crushing circumstances or if operated with atypical efficiency). The same holds for electric buses in exclusive lanes, streetcars and surface trains. If operated in similar conditions, the only significant differences in these four modes are: (1) the greater flexibility of diesel buses; (2) more energy waste and pollution from diesel buses; and (3) different investment and maintenance costs. The upshot is that metros will seldom be recommended in Latin America if the characteristics approach is used. Using Stone's rule of thumb that it costs 10 times as much to construct a railroad underground than on the surface, it makes sense to build 10 km of surface rail rather than 1 km of metro, and to resort to underground or overhead sections only in the most extreme circumstances. Rehabilitating existing rail systems is likely to be an even greater bargain. If new lines are needed, the electric bus can furnish the same characteristics on existing roadways with lower investments and less implementation time. Brazilian trolley buses also have energy requirements similar to metros, due to lower speeds, although they now have the disadvantage of operating in mixed traffic.

Energy efficiency calculations should also consider the source, foreign exchange requirements and specific occupation factors. Although trolley buses are likely to be Brazil's best alternative, given its available hidroelectric energy and shortage of capital and exchange, the diesel bus can provide similar service in the short run at the cost of lessened energy effectiveness and more noise and air pollution. High occupation factors for Latin American vehicles result in greater energy efficiency than for their European counterparts. For example, if the crowded Rio de Janeiro area surface train's calory consumption per passenger.km is taken as the base factor (=1), Brazilian buses have a factor of 3, English metro = 4.9, English train = 6.7, English double deck bus = 9.8 and cars in both countries vary in the range of 12 for four passengers to 29 for driver only.[7] These considerations imply the need for Brazil to shift from the present excessive reliance on buses and cars to a larger number of electric buses and improved surface rails as financial constraints permit, given that its industry is capable of producing almost all the infrastucture and vehicles locally.

Fifth, the adequacy of the characteristics of the various modes depends heavily on the way they are operated, the norms for designing and using rights-of-way and the surrounding areas, public policies and investments, and the specific socio-economic situation. These factors are an integral part of the characteristics approach, since they often provide the most cost-effective means of improving the set of transportation and urban characteristics. An exclusive bus lane involves little physical construction - it basically represents a change in the underlying assumption of whether people or vehicles have priority in the use of urban space. If vehicles have priority, private cars

---

[7] English figures from a British study summarized in Revista dos Transportes (Mar. 1980), Rio train from 1976 Federal Railways (RFFSA) statistical yearbook, buses and cars from specific consumption and occupation factors.

will clog the city's arteries, since they use urban space so inefficiently. Cheap fuel policies have brought Mexico City's traffic to a near standstill, with an accompanying air pollution problem. In Rio, high fuel prices have discouraged auto use and actually improved traffic flow in recent years. If people are given priority over vehicles in the competition for limited urban space, policies will favor the modes with greatest capacity. Implanting exclusive lanes for buses and bikes and pedestrian malls, banning cars from parts of CBDs, limiting auto parking and increasing fuel taxes all favor smooth circulation of more people and energy efficiency. São Paulo has adopted such measures in recent years and increased the average speed of its buses in some areas from 5 km/h to 20 km/h. Singapore has taken more drastic action and limited the number of automobiles by legislation (Watson and Holland).

Similarly, the characteristics approach encourages the systemic search for better alternatives and lower costs. Small changes in norms, policies, vehicles, operating practices or the environment can produce big differences. In the Maceió case, for example, GEIPOT's urban transport technicians noticed that many CBD streets had irregular widths, such as 2.5 traffic lanes. The useless half-lane was employed to transform the sidewalks from a mere half-meter in some points into wider and safer passageways. Some major arteries could easily lose a few inches from each lane to plant flowers, hedges or trees at their edges, producing lower noise levels, a more pleasant urban environment, a discreet separation of pedestrians from vehicles, and less dangerous jaywalking by guiding pedestrians to elevated passages or signalized crossings. Ticket selling may be placed outside the buses, and vehicles can be equipped with several wide doors, speeding both access and travel time.

4. THE UTILITARIAN PRINCIPLE, DECISION MAKERS AND THE (HIGH-INCOME) MINORITY

The traditional benefit-cost approach to evaluation of urban transport projects has been shown to be unsupported by economic theory and inconsistent with coherent principles of planning. Its limitations are especially severe in Latin America due to the area's pronounced income inequality, municipal budget restrictions and high density urban populations which yield high levels of congestion despite moderate car-ownership levels.

This paper has developed a characteristics approach as an alternative method of planning and evaluation for urban transport. It is consistent with accepted planning guidelines, by focusing initially on the definition of problems and goals, and explicitly recognizing the need to use public funds in a limited and austere way. The method explicity chooses the principle of progressivity in taxation and expenditure of public funds, by adopting the utilitarian motto of the most good for the greatest number, with the addendum that the rest of the population should suffer the least possible disadvantage. Two questions, however, remained unanswered.

The first is whether decision makers will understand the characteristics approach or merely be confused by it, as one benefit-cost advocate has suggested. This of course begs the question of whether they ever understood B/C analysis in the first place. Few politicians, lawyers or military personnel, for example, understand what discounting, shadow-pricing or Paretian optimality are all about. The author has given up trying to teach the latter two concepts to undergraduate economics majors after several valiant but unsuccessful tries. Thomson indicates that many were unaware how metro project benefits and costs were being overestimated and underestimated, respectively. In any case, a positive response is in order regarding comprehension of the characteristics approach. The relevant transportation characteristics (summarized here in Tables 1 and 2 and the discussion on energy efficiency per passenger-km) can be easily explained to office holders and the general public. This explanation, moreover, is a vital part of providing them with the information required to understand the basic factors associated with the various transport modes. Such information is indispensible for making intelligent choices among numerous alternatives,and reflects our earlier finding that information is a key variable in transport planning, rather than a given parameter. Both office holders and the public may be expected to understand that the new approach consists of a systematic search for a better set of characteristics at the least possible cost. And they will appreciate having some options to choose from, with measures and projects that can be undertaken now (even though city hall is nearly insolvent), and others that can be undertaken later if finances improve or federal funds are obtained. At the technical level, multidisciplinary teams will now have a method which integrates their efforts and directs them toward common, socially desirable goals. Stone complained some years ago that the planning process had been delegated to civil engineers, while urban planners, architects and mechanical engineers were neglected entirely or consulted when it was already too late to change the project. Stone omitted economists from the discussion altogether - perhaps supposing that they were merely justifying decisions that had already been made or that no-one would understand them. In Latin America this situation has been especially severe since engineers have a heavy professional orientation toward physical construction projects,and their only course in transportation is normally dedicated to building roads, while economists often have no training in transportion. After having tested these ideas on laypersons, students and technicians of diverse backgrounds for several years, I have found that both the essential modal characteristics themselves and the characteristics approach to planning and evaluation are easily assimulated. The economist can now become part of the planning team from the initial discussions onward, since planners, engineers and archetects understand and appreciate what he is doing for the first time - helping to evaluate the costs and budget restrictions for different alternatives for providing the public with better transport characteristics.

The second unresolved question is if the characteristics approach is inadvertently an attack on automobiles and their owners. The reply appears to be no. The strict Paretian criterion that no-one should be left worse off as a result of a transport alternative choosen may in fact be very closely approximated by the characteristics approach. The attempt to make a densely populated urban environment accept an increasing number of automobiles is, after all, a self-defeating strategy. By limiting the space available to autos and charging more for the use of that space, cars will be used more judiciously and the service level obtained will be better. Furthermore, as the characteristics approach shows, the auto-owner's welfare is affected in many different ways. He or she is also a part-time pedestrian with a spouse and children who are pedestrians, cyclists and transit users, and all are full-time urban residents and citizens who are affected by the city and nation's financial health. Since the characteristics approach promotes betterment of all these aspects, the auto-owner may in fact be more favorably affected by the promotion of public transportation, walking and cycling than by car-oriented strategies.

REFERENCES CITED

AHLUWALIA, Montek S., 1976, "Inequality, Poverty and Development". Journal of Development Economics 3:307-42.

DEPARTAMENTO DE TRÂNSITO DO DISTRITO FEDERAL(DETRAN-DF), 1978, "Boletim Sobre Segurança de Tráfego".

DUARTE, José de Vasconcelos, 1979, "Triálogo". Correio Braziliense (Brasília), 10 Jan., p.24; "A Bicicleta? A Bicicleta!" (Brasília, oct.1979, xerox).

GALBRAITH, John Kenneth, 1971, The New Industrial State. New York: Mentor.

HARBERGER, Arnold C., 1971, "Three Basic Postulates for Applied Welfare Economics: An Interpretative Essay". Journal of Economic Literature 9: 785-97.

INSTITUTE OF TRANSPORTATION ENGINEERS, 1976, Transportation and Traffic Engineering. Englewood Cliffs, N.J. (U.S.A.): Prentice-Hall.

LANCASTER, Kelvin J., 1966, "A New Approach to Consumer Theory". Journal of Political Economy 74 (April):132-57.

MANHEIM, Marvin L., 1979, Fundamentals of Transportation Systems Analysis. Cambridge, Mass.: MIT Press.

MISHAN, E.J., 1975, Cost-Benefit Analysis - An Informal Introduction. London: George Allen & Unwin, Ltd.

MOISÉS, José Álvaro, and Verena Martinez-Alier, 1977, "A Revolta dos Suburbanos". In José Álvaro Moisés et al. (eds.), Contradições Urbanas e Movimentos Sociais. Rio de Janeiro: Editora Paz e Terra.

MUMFORD, Lewis, 1964, The Highway and the City. New York: Harcourt, Brace and World.

MYRDAL, Gunnar, 1969, Objectivity in Social Research. New York: Pantheon Books.

SAMUELSON, Paul A., 1976, Economics. New York: McGraw-Hill, p.9-10.

STONE, Tabor R., 1971, Beyond the Automobile: Reshaping the transportation Environment. Englewood Cliffs, N.J. (U.S.A.): Prentice-Hall.

THOMSON, Ian, 1980, "The Biasing of Transportation Planning in Latin America for the Benefit of Higher Income Citizens: An Introductory Investigation". Paper presented at the Developing Countries Seminar, Summer Annual Meeting of Planning and Transport Research, University of Warwick, England (July). Idem, "Algunos Aspectos de la Justificación Sócio-Económica de los Ferrocarriles Metropolitanos en América del Sur", CEPAL, Santiago, Chile (xerox).

WATSON, Peter L., and Edward P.Holland, 1978, "Relieving Traffic Congestion: The Singapore Area License Scheme". Washington, D.C.: World Bank Staff Working Paper Nº 238 (June).

WORLD BANK, 1975, "Urban Transport: Sector Policy Paper". Washington, D.C..

WRIGHT, Charles L., 1978, "Income Inequality and Economic Growth: Examining the Evidence". Journal of Developing Areas 13 (Oct.):49-66.