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AN ANALYSIS OF SOME OF THE SOCIAL CONSEQUENCES  
OF THE AUTOMOBILE IN LATIN AMERICA

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## I. SUMMARY AND CONCLUSIONS

The purpose of the paper to which this is the introduction is to investigate the nature of the relationship between the private automobile and society in Latin America. The report makes no attempt to quantify the benefits conferred by the use of the private car; these are undoubtedly significant but their quantification is not easy. In an appendix, however, we present a methodology by means of which such benefits could be estimated. But much is said about some of the undesirable features of lifestyles which revolve around the private car. We are aware that the concentration on the malefics and the comparative disregard of the benefits may lead the reader to the drawing of biased conclusions. It is only fair to point this out; we have not been able to present a more balanced picture of the position of the automobile in Latin America due to a lack of resources.

The treatment is specifically directed to the private automobile, rather than the net being cast wider so that all motor vehicles be included. The fundamental reason for such restriction was not to simplify the study; in fact the need to separate out a consequence attributable to the private car from global information on vehicle fleets tended to complicate matters. The private car is fundamentally different from other vehicles in that the benefits from its use accrue largely to the user alone. On the other hand the benefits from buses tend to be passed on to anyone who jumps on board, and the fares of buses in Latin America are not such that buses be solely a preserve of a privileged class. In the perfectly competitive world which often surrounds bus operation in the Region, the owner of the bus may not reap any reward other than a nothing-more-than adequate return on his capital and energies. In the same way the benefits derived from the services performed by trucks and vans accrue to those who consume the products conveyed by them, rather than any one class of persons gaining all the reward. In some countries, such as the United States of America, it may not be true that truck owners and operators do not benefit from the distorted nature of the supply function of their industry, but in Latin America trucking is rarely excessively regulated (except in international trade) and the owner gets nothing more than his fair return on the services which he provides.

/But all

But all vehicles force costs on society in various ways. They may create congestion, they may stimulate the demand for more infrastructure, they kill and maim their occupants and innocent bystanders, and they pollute the atmosphere. Only the car results in the benefits being concentrated in the hands of its owner whilst inflicting social costs on us all. It is clear that the benefits from car usage may be diffused throughout the populace, through taxation, but this rarely occurs in a sufficient degree, not in Latin America at any rate.

The paper is divided into six chapters over and above this introduction. These sections are summarized as follows.

**Section II** In section II we present some results from statistical analyses of car ownership in 27 Regional and non-Regional countries in the years 1950, 1962, and 1974; appendix 1 provides information of the statistical analyses performed. The principle result from the analyses is that there exists a tendency for all countries to become increasingly alike as regards car ownership, in the sense that the number of cars per head is more and more explicable by means of income per head (through the proxy GDP per head) alone as time passes. Inter-country differences of social and economic structure are becoming steadily less influential. Countries are seemingly tending to adopt the same kind of lifestyle, a focal point of which is the private car.

From 1950 to 1962 and again from 1962 to 1974, the number of cars owned per person increased at given real income level.

This provides evidence that not only are countries taking on a similar style of living but this style is evermore dependent on the automobile. Further results drawn are: the splitting of growth in car ownership between the effect of income growth, and a secular trend independent of income; and the derivation of income elasticities for car ownership.

**Section III** In section III are presented forecasts of car ownership rates by country in Latin America to the year 2000. Two sets of forecast are made. The first assumes that the annual rate

/of change

of change in the propensity to own a car at given real income per head observed from 1962 through 1974 will continue henceforth. The second assumed that the factors leading to higher car ownership at given real income had worked themselves out by 1974.

Section IV In this section we investigate, in a necessarily somewhat superficial manner, whether automobile ownership and usage has any contribution to make towards overall economic growth. In some ways it has a negative impact: for instance it reduces the amount of foreign exchange which may be spend on development projects, especially through the need to feed the car with gasoline; furthermore the inability of many Latin American families to pay cash for cars may reduce the amount of, and increase the costs of, credit for development projects; the automobile may also have the impact of leading to an undersirable expansion of the public sector. On the positive side one should count the employment provided by the industry of car construction and upkeep, much of which may otherwise not be fully utilized in other sectors. These activities also serve the useful function of raising the level of skills in the economy. However, employment in the motor vehicle sector in Latin America never reaches appreciable significance, and the concentration of considerable power amongst the workers of assembly plants can lead to undesirable economic, as well as social, consequences.

Section V Section V traces the evolution of transportation in the cities of the Region. The private car is only one of the revolutions which have occurred in the cities of Latin America in the field of transportation, although it may be unique in being the only novel mode which has made conditions worse rather than better, although metros may be argued to have the same unfortunate characteristic in view of their alarmingly high costs. The cities of the Region were long dominated by the tram/street-car/bonde/tranvia. As late as 1950 in at least one capital  
/city of

city of the Region bondes carried more people than any other mode. The fall of the tranvia was very rapid. It was largely replaced by the more flexible motor bus, which was a very late arrival in Latin America, but which since the second world war has produced a revolution at least comparable with that of the private car. In Latin America, bus systems are very different from those of the central countries. Rail systems have been important in some cities. There has recently been a fashion for metros, which has produced some disillusionment. New ideas are being sought, one of which could be the trolleybus, which has so far led a somewhat checkered history in Latin America.

Section VI. In this section we analyse to what extent car ownership is concentrated in Latin America. It is found to be highly concentrated in the highest income categories. The nature of spatial economic structure of Latin America infers that there be concentration too in the areas with the highest demographic densities. Thus cars are concentrated where they cause the most environmental harm; and this harm is inflicted on all by an affluent privileged minority. The more affluent are found to make excessive demands on the urban transportation system, on four counts:

- (i) They make more trips since trip-making is positively correlated with income.
- (ii) They make more trips since they have higher probabilities of being car-owning, and car ownership itself leads to increased trip-making at any income level.
- (iii) They make more of their trips by car, which is wasteful in terms of road space.
- (iv) In Latin America the more affluent seem to concentrate their trip-making in the peak periods, when road space is especially at a premium.

The trip-making habits of the rich force inferior travel conditions on the captive users of collective transportation.

/The responsible

The responsible authorities have never attempted to oblige car users in congested conditions in Latin America to pay the costs of the harm they inflict on society, even though at least one study has been conducted in the Region recommending a workable scheme of so doing. There is some recent evidence that certain cities are starting to adopt physical methods of giving priority to bus traffic, although this seems to usually be fostered by a concern for things other than the nuisance caused by the private car in terms of the congestion it generates. But in most cities, attempts to improve collective transportation have generally tried to avoid disturbing those who wish to use the private car. Thus recourse has sometimes been made to unnecessarily expensive solutions, such as Metro systems. The private car is treated as a kind of Latin American sacred cow, which must not be tampered with.

Section VII. Section VII deals with some effects that the car has on health, through highway accidents, and air and noise pollution. Generally, the highways of Latin America are very much more dangerous than those of the central countries. The reasons why are not known for sure, but they seem to include inferior roads, vehicles not up to the current safety standards of the central countries, inexperienced drivers, and the preponderance of vehicle types which are inherently less safe than others. In this respect, it should be mentioned that it appears that, whilst the private car is less safe than the taxi in respect to the probability of being involved in an accident, trucks and buses are considerably more dangerous than the private car.

In the central countries the evidence shows that the gasoline powered car is by far the most liberal diffuser of possibly toxic gases into the atmosphere, especially carbon monoxide and nitrogen oxides. The situation is less clear in Latin America where many buses and trucks are gasoline powered, in some countries, and badly regulated motors are prevalent. Certainly

in one capital city of the Region, the car is a relatively insignificant polluter compared with buses and taxis. But nevertheless some of the countries of the Region have been concerned enough about the pollution problem to have enacted legislation designed to combat the problem. Unfortunately the intent of the legislation has sometimes been different from the outcome of its application.

Noise pollution from cars is not important compared with that from other vehicles. Latin America seems to rather deny that there is a problem of noise pollution from traffic, and in any case it is not easy to visualize an effective solution were any problem to be deemed to exist.

If there is an overall conclusion to be made it is that, regardless of the benefits which the owner of the private car reaps from its use, the automobile in Latin America should be made responsible for the costs which it forces upon society, preferably through pricing schemes designed to bring user costs up to the level of the full social costs caused. The revenues could be circulated to those who are disadvantaged, often the collective transportation rider.

Latin America needs a series of benefit: cost analyses of the forms of lifestyle which involve varying amounts of reliance on the private car. The Region may not be best served by the unthinking drift into the North American consumerist way of living which revolves around the car. The car is an increasingly expensive piece of equipment. It is at least possible that Latin America in general never reach the levels of car ownership currently found in even the middle income countries of Western Europe, largely due to the energy crisis. It may be worthwhile to start considering what are the alternatives.



## II. POST WAR GROWTH IN CAR OWNERSHIP IN LATIN AMERICA

In all parts of the world the most visual representation of post war economic prosperity is the automobile. Latin America is no exception to the global trend towards the car-owning consumerist society on the North American model. Nevertheless it is still, in the main, a long way from reaching this goal essentially due to higher car prices in Latin America than in the central countries which have led the consumerist revolution and the combination of lower general incomes in the Region with a more skewed income distribution. However the desire to follow the North American style of life seems probably even stronger in Latin America than in countries in similar stages of development elsewhere.

In the late nineteen forties and early nineteen fifties car ownership levels in Latin America varied up to twenty cars per thousand persons, but only Venezuela, Argentina and Uruguay (amongst 17 Latin American nations analysed) had ownership rates greater than ten. In the same period car ownership in the United States of America was over 250 per 1,000 persons whilst the European levels ranged up to fifty. The Australian level was around the hundred mark whilst Japan was virtually at zero. Table 1 shows car ownership rates in 27 countries, including 17 in Latin America, in the years 1950, 1962 and 1974.

To 1962 the percentage growth rates in car ownership in Latin America tended to be less than those in most of the central countries. Thus Latin America generally fell behind in car ownership both in relative and absolute terms. In the period from 1962 to 1974 there has been evidence in some of the central countries that growth rates have been tailing off as the supposed saturation level of car ownership approaches. Growth rates in Latin America have tended to be higher. But nevertheless ownership levels in Latin America are currently very much less than those in the central countries. In 1974 car ownership in the Latin American countries considered ranged from 5 to eighty cars per thousand persons whilst the corresponding figure in the United States of America was almost 500 and in Western Europe around 300. Thus Latin America is not yet a mass consumer of cars, and may never be so. In Latin America car ownership in most countries is concentrated in the upper

tail of the often markedly skewed income distribution. However in the city centers of the Region there often appear to be more cars than there are in the centers of the central countries due to the greater permissiveness regarding the use of cars in Latin America. Latin America has as many problems generated by cars as has Europe or North America, even though the physical size of the fleet in Latin America is very much less. We have analysed car ownership propensities in 27 countries, including 17 in Latin America, in the three evenly-spaced of 1950, 1962 and 1974. For each year a statistical function of the same form was calibrated relating car ownership per head to GDP per head in constant US dollars. The form of the function is:

$$\text{Cars per head} = \frac{\text{Saturation level of cars per head}}{1 + aY^b} \quad (1)$$

where Y is GDP per head and a,b are constants calibrated to best fit the data. The functions are plotted as Figure 2-1. In contrast to some other research of this general type the saturation level of ownership was not determined by reasoned deduction from observation of actual ownership levels in different places with high per capita income levels but rather we calculated the equation for various saturation levels (for each year) and chose the one which gave the best fit to the data. The resultant saturation levels are higher than those assumed in the few known previous analyses (for forecasting fleet-size) but there are valid reasons to justify them and in any case they will only be approached at income levels that the world will probably never attain over more than a few square meters.

Details of the statistical exercise are contained in Appendix 1. From it one may draw certain interesting results. We discuss these below.

1. Firstly the coefficient of regression ( $r^2$ ) increases through time 1/ thereby indicating that countries are tending to take on similar characteristics at given income level with respect to car ownership. There are several reasons which may be proposed to explain this. In 1950 to a significant degree car ownership levels were distorted due to the effects and aftereffects

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1/ From 0.843 in 1950 to 0.925 in 1962 to 0.977 in 1974.

of the second world war. Certain countries, notably the United States of America, were comparatively little affected by the war and in 1950 possessed car ownership levels significantly above those which one would have expected from the function estimated from the data for all countries. The European countries were obviously the most devastated by the war (as well as Japan); even those not directly involved could neither renew nor expand their fleets. The Latin American nations did not choose to involve themselves in the war, with the notable exception of Brazil, but even so could not buy vehicles from the belligerents, which in those days were the only manufacturers of motor vehicles (apart from Sweden). During the war some Latin American nations, notably Brazil and Argentina, accumulated reserves of foreign exchange through selling on differed terms goods to the nations at war. Immediately after the war such vendor nations imported quite large quantities of motor vehicles until the early nineteen fifties when supplies of foreign exchange ran out and imports of cars were severely cut back. For example imports of cars to Argentina climbed from almost zero in 1945 to 31,000 in 1947, almost double any subsequent figure. Thus Latin American nations in general and some, such as Brazil and Argentina in particular, would have been expected to have more cars per head than one would have foreseen from their 1950 per capita income levels due to the combined effects of the relative immunity from the effects of the war and the importation of cars in the immediate after war period. Table 2-1 indicated that amongst the Latin American countries with significantly higher than expected car ownership rates in 1950 were Brazil, Argentina, Peru, Costa Rica, Venezuela, the Dominican Republic, and El Salvador.

On the other hand in this year other countries, such as Bolivia and Paraguay, had very much lower car ownership than one would have expected. Both of these countries had very low per capita income levels in this period. There seems to be a close correlation between countries with lower than expected car ownership and countries with low per capita incomes. Some of this is probably due to the form of the statistical relationship calibrated but it is also probable that these countries had not yet entered into the kind of lifestyle which revolves around the automobile that had then spread from the United States of America into other countries of the Region, notably

Table 2-1

OBSERVED AND ESTIMATED OWNERSHIP LEVELS BY COUNTRY FOR THE THREE YEARS CONSIDERED FOR DETAILED ANALYSIS  
WITH RESPECTIVE REAL PER CAPITA DOMESTIC PRODUCT DATA

Country	Z 1950	Ẑ 1950	Z 1962	Ẑ 1962	Z 1964	Ẑ 1974	Y 1950	Y 1962	Y 1974
Argentina	18.5481	13.698	29.3871	31.276	80.9284	80.334	817	932	1 399
Bolivia	0.6293	1.269	1.9202	2.008	4.6181	5.138	231	198	293
Brazil	4.8561	1.290	10.8157	5.960	35.5810	20.611	233	364	636
Chile	6.5558	7.121	9.1459	19.943	23.3711	34.628	576	720	554
Colombia	3.1910	3.093	7.8427	8.420	14.1138	17.767	370	442	585
Ecuador	1.2070	1.441	2.4073	4.222	6.3501	10.421	247 <sup>b/</sup>	800	434
Paraguay	0.5957	2.147	2.6781	4.554	6.7653	7.410	305	313	359 <sup>b/</sup>
Peru	3.9752	2.255	9.2980	9.109	17.5235	18.038	313	462	590
Uruguay	19.7282	15.929	39.8388	27.038	49.2358	36.054	886 <sup>a/</sup>	857	874 <sup>c/</sup>
Venezuela	13.5277	9.011	33.9602	33.514	78.2117	70.488	653	970	1 293 <sup>c/</sup>
Costa Rica	5.9441	2.740	13.3183	9.966	28.7578	29.216	347	486	775
Dominican Republic	1.8213	1.259	4.4489	4.606	12.7884	11.611	230	315	461
El Salvador	2.2620	1.646	8.2907	5.558	10.1889	10.164	265	350	428
Guatemala	2.5828	1.990	7.4751	5.004	11.6947	12.389	293	330	478
Honduras	0.9358	1.280	2.7785	3.070	5.3738	4.795	232	251	282
Mexico	6.5023	5.173	13.1952	16.392	35.8931	44.906	486	644	992
Nicaragua	1.3526	1.108	5.1923	4.323	15.1659	11.031	215	304	448
United States	264.7984	149.082	351.8833	278.235	492.296	461.462	3 180	3 798	5 174
Australia	43.8187	42.593	214.2559	128.307	355.2664	275.846	1 516	2 187	3 208
Sweden	36.0553	77.233	188.7593	210.421	329.526	404.537	2 127	3 088	4 499
Switzerland	31.3166	59.785	117.1709	165.798	278.670	298.442	1 835	2 594	3 419
France	35.9400	33.811	147.8824	111.824	87.455	295.791	1 334	2 002	3 394
United Kingdom	45.7760	35.437	127.5722	92.348	253.676	178.698	1 369	1 775	2 332
Japan	0.5139	2.983	9.3628	29.325	144.2600	174.385	363	898	2 293
Federal Republic of Germany	12.5612	26.158	111.7756	134.560	275.495	291.534	1 159	2 256	3 354
Holland	13.7038	28.005	61.7077	86.783	233.124	229.987	1 203	1 708	2 791
Belgium	31.7166	34.643	99.0363	101.419	255.046	272.920	1 352	1 882	3 181

Notes: Z = cars per 1 000 persons (observed).  
Ẑ = cars per 1 000 persons (synthesized).  
Y = GDP per head in US\$ of 1970.

a/ Data point refers to 1951.

b/ Data point refers to 1971.

c/ Data point refers to 1975.

/Venezuela. There

Venezuela. There is a tendency for those countries with low rates of car ownership in this period in relation to income also to have low rates of urbanization, although statistical proof of association has not been attempted.

By 1962 there were fewer and less marked deviations from trend, the regression coefficient having increased from 0.843 in 1950 to 0.925 in 1962. And, as Table 2-2 shows, the number of countries significantly deviating from the expected trend decreased markedly over the twelve year period. In Latin America, Brazil and Argentina, both of which had significantly greater car fleets in 1950 than one would have expected from their income level (due to the effects and aftereffects of the war and other reasons), severely curtailed their car imports in the period to 1962. For instance, in the nineteen fifties imports to Argentina never in any one year attained hardly more than half their 1947 total, and varied widely, as low as two thousand in some years, depending on the strictness of the regulations then current regarding importation. In 1962 neither Brazil nor Argentina had been producing cars on any scale for long. Argentinian production was less than 4,000 in 1958, less than 7,000 in 1959 but then climbed sharply to attain close to eighty thousand in 1962. In 1962 Brazil was still producing fewer cars than was Argentina and clearly not enough to satisfy the demand of that country (at reasonable prices). Thus the extent to which both Brazil and Argentina were over trend in 1962 was less than in 1950. In the cases of those countries with lower per capita income, which in 1950 were somewhat isolated still from the pursuance of the North American style of consumer society, such as Bolivia, Paraguay and Honduras, by 1962 were approaching the expected values for their income range from below. Their relatively rapid growth in car ownership may have had something to do with the growth in the amount of usable infrastructure, the construction of which is to some extent an indication of the goal of a consumerist lifestyle.

By 1974 the regression coefficient had increased to 0.977 and most of the 27 countries considered had ownership levels within about 14% of the expected, as may be deduced from Table 2-2. By this year the industries of Brazil and Argentina were producing relatively efficiently and were able to keep supplied their home markets. Chile, which in 1962 was significantly below trend due to difficulties of importing cars due to foreign exchange

/crises, was

crises, was producing cars domestically by 1974. Also this country had suffered a setback in economic growth which had tended to bring its income level into line with its car ownership level. Uruguay had a relatively high ownership level in relation to income due to the same cause, in part at least, as had the United Kingdom outside the Region.<sup>1/</sup> In these two latter countries the relatively even income distribution may have played a part in explaining ownership levels. Ecuador was below the trend to a noticeable degree due probably to the fact that car acquisition had not managed to catch up with the recent boom in that country brought about by its exploitation of its petroleum reserves and the rise in the international oil price of 1973.

2. The second interesting result from the calibration of the functions is the increase in ownership at constant real income as time passes. Note too that the saturation rate is 800 cars per 1,000 persons in 1950 but 900 in each of the two subsequent years. The reasons for the higher propensity to own cars at fixed real income are the following:

(i) In general there was a tendency for car prices to fall throughout the period. This was certainly true in the central countries due to increasing scale economies. In Latin America too, for those countries which currently produce cars one may observe a tendency for, at first, real car prices to fall in the immediate post-war period. Then exchange crises caused the elevation of import duties (and other barriers affecting prices), partially to stimulate the production of cars locally. The local production had to be able to sell at less than the price of the imported product, thus the arrival on the local market of the first domestic vehicles resulted in a fall in prices. Increasing scale economies and competition steadily lowered prices; for instance real prices of cars in Argentina fell continually (from very high level) from 1960 through 1972. Furthermore, with the development of car ownership, used car prices tend to fall, which in turn stimulated ownership amongst those who cannot afford a new car.

(ii) There was probably a like fall in car operating costs. Crude petroleum prices fell continuously from the early 1950s to 1973. An

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<sup>1/</sup> Also these countries in 1974 had a relatively high number of cars bought in earlier years when their income levels were little less.

increasing car fleet size brings with it economies of scale in maintenance. In Brazil there must have been a significant reduction in maintenance costs due to the spread of cars such as the VW Beetle, the Auto-Union DKW, and the Renault Dauphin in place of the previous collection of elderly cars from the United States and elsewhere. Throughout the period intervals between maintenance and oil changes increased.

(iii) Until 1974 one may discern a policy of providing for the car rather than limiting its use. For instance urban freeway construction continued apace in many cities such as Caracas and Rio de Janeiro. Brasilia's transportation system was an attempt to provide enough road space to meet the demand for car use. On the other hand serious attempts to limit car usage even in the centers of the largest cities are very recent, and sometimes are yet to come. Were there to have been a policy of controlling car usage it is possible that ownership would have been affected. However, outside the Region such control started much earlier.

(iv) In the central countries quality of collective transportation generally declined throughout the period. This could have affected car ownership, especially the ownership of second cars. In Latin America the situation is less clear, and the levels of accessibility by public transportation may not have fallen much, if at all, in the overall sense. But the events in the central countries would have affected the equations anyway.

(v) The change in lifestyles so that a car is thought upon as a necessary article of consumption rather than a foreign object that is seen on the streets rather than parked in front of one's home. The older generations may not have considered the possibility of learning to drive. Their lifestyles were adapted so that they had no cause to need a car. Constantly throughout the period the gaining of a licence to drive became as much a part of a child's education (in the central countries which influence the form of the calibrated equations) as learning how to use an escalator or switch on a television. City patterns changed so that residential densities fell and collective transportation services declined in quality as more and more of the local population owned cars thereby stimulating others to do the same. In some countries it became steadily more easy to shop by

/car and

car and steadily more difficult to shop on foot or by bus. In Latin America through the media of the cinema and television the way of life of the central countries became more well-known and pictured as the goal to be attained.

It is probable that the change in lifestyles in favour of those which revolve around the private car was the main contributant to the upward movement of the calibrated function throughout the period covered.

Table 2-2

NUMBER OF COUNTRIES RECOGNIZED IN THE CALIBRATION OF THE EQUATIONS TO EXPLAIN CAR OWNERSHIP AS A FUNCTION OF INCOME WHICH DEVIATED FROM THE TRENDS IN THE THREE YEARS CONSIDERED, 1950, 1962 AND 1974

Degree of deviation	Number of countries corresponding to the category in:		
	1950	1962	1974
Very much lower ownership than trend <u>a/</u>	6	2	0
Considerably less ownership than trend <u>b/</u>	2	4	2
Somewhat less ownership than trend <u>c/</u>	1	2	4
No difference from trend <u>d/</u>	4	9	16
Somewhat higher ownership than trend <u>e/</u>	5	4	1
Considerably higher ownership than trend <u>f/</u>	6	6	4
Very much higher ownership than trend <u>g/</u>	3	0	0

Source: Annex 1.

- a/ Minus 50% and less.
- b/ Minus 25% to minus 50%.
- c/ Minus 13% to minus 25%.
- d/ Plus 15% to minus 13%.
- e/ Plus 33% to plus 15%.
- f/ Plus 100% to plus 33%.
- g/ Plus 100% and more.

3. Thirdly, one may manipulate the calibrated equations to derive the elasticity of per capita car ownership with respect to per capita real income for each of the three years, in this way deriving further interesting

/results. In



results. In the derivation of the elasticities, as Appendix 1 explains, we have considered that as a country increases its per capita income it does not change its demographic structure, so as to concentrate solely on the effect of income. (As a clarification of this latter point, countries with lower per capita income generally have lower percentage of persons of such an age that they be likely to own a car than countries with higher incomes. But we have assumed that as a country which presently has a demographic structure of "x" gets richer it maintains this same demographic structure rather than take on the structure of countries which are currently richer than it is now.) Table 2-3 details the elasticities derived.

In each year the elasticity first rises and then falls as income per capita increases. At low income levels a rise in incomes is insufficient to bring many people into the car-owning range regardless of the income distribution. After the peak interaction has been attained the elasticity steadily declines as extra income is spent on other things due to the increasing probability that a family already own a car. The income at which the relationship between car ownership and income falls below proportionality is about US\$ 5,750 (in 1970 dollars) in 1950 but only US\$ 3,900 in 1974. Elasticities generally fall through time at fixed income level. Thus one would conclude that as time passes (over the period considered) the propensity to own a car at any given income level rises but that the impact on car acquisition of changes in income falls.

Table 2-3

THE ELASTICITY OF CAR OWNERSHIP WITH RESPECT TO INCOME (APPROXIMATED BY GDP) BOTH EXPRESSED IN PER CAPITA TERMS IN 1950, 1962 AND 1974 AT VARYING PER CAPITA INCOME LEVELS

Income per capita in US dollars of 1970	Elasticity of car ownership in:		
	1950	1962	1974
200	1.72	1.61	1.63
500	1.73	1.62	1.64
750	1.72	1.61	1.62
1 000	1.71	1.59	1.59
1 500	1.67	1.52	1.50
2 000	1.61	1.45	1.40
3 000	1.45	1.27	1.18
4 000	1.28	1.09	0.98
5 000	1.12	0.92	0.80
6 000	0.96	0.78	0.65

Source: Annex 1.

4. Fourthly, one may use the calibrated functions to partition growth in car ownership into that part for which income growth is responsible and that part which is due to the increase through time in the propensity to own cars at given fixed income level. There are two ways to do this. Once one has assumed a growth (or fall) in per capita income from one year to another (e.g., from 1962 to 1974) one may derive the time effect by moving from one curve to the other at fixed income and then estimate the income effect by moving along the latter curve from the initial income to the subsequent one. Alternatively one may first move along the curve for the initial year and then switch curves at the income level of the subsequent year. We used the first method to determine, for each country and from each possible starting year, i.e., 1950 and 1962, the part of the expected 1/

1/ I.e., assuming that it be exactly on the curve, with car ownership corresponding to the observed income data for each year.

change in car ownership which one may be attributed to non-monetary factors which evolve through time and the part due to income growth. In general the conclusions are that from 1950 to 1962 the greater part of the growth in car ownership in Latin America was due to the influence of time (and more fundamentally change in lifestyle, etc.) whilst in the central countries the opposite was true, i.e., income being the more important influence. The latter result was even more valid for the central countries between 1962 and 1974. Between the latter two years the growth in car ownership in Latin America too was essentially due to the effect of income. The exceptional case is thus Latin America between 1950 and 1962.<sup>1/</sup> This indicates that perhaps the change in lifestyles in favour of consumerism on the North American style in this earlier period in Latin America had a fundamental impact on the growth in car ownership.

The calibrated equations, apart from permitting a greater insight into the determinants of car ownership in Latin America during the post-war period, also may be used to predict car ownership into the future.

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<sup>1/</sup> Table 2-4 shows the results of the exercise to partition growth in car ownership by causant factor.

Table 2-4

TO SHOW TIME AND INCOME COMPONENTS OF OWNERSHIP GROWTH a/  
1950-1962 AND 1962-1974 BY COUNTRY AND COMPARISON OF  
TOTAL ESTIMATED CHANGES WITH OBSERVED CHANGES

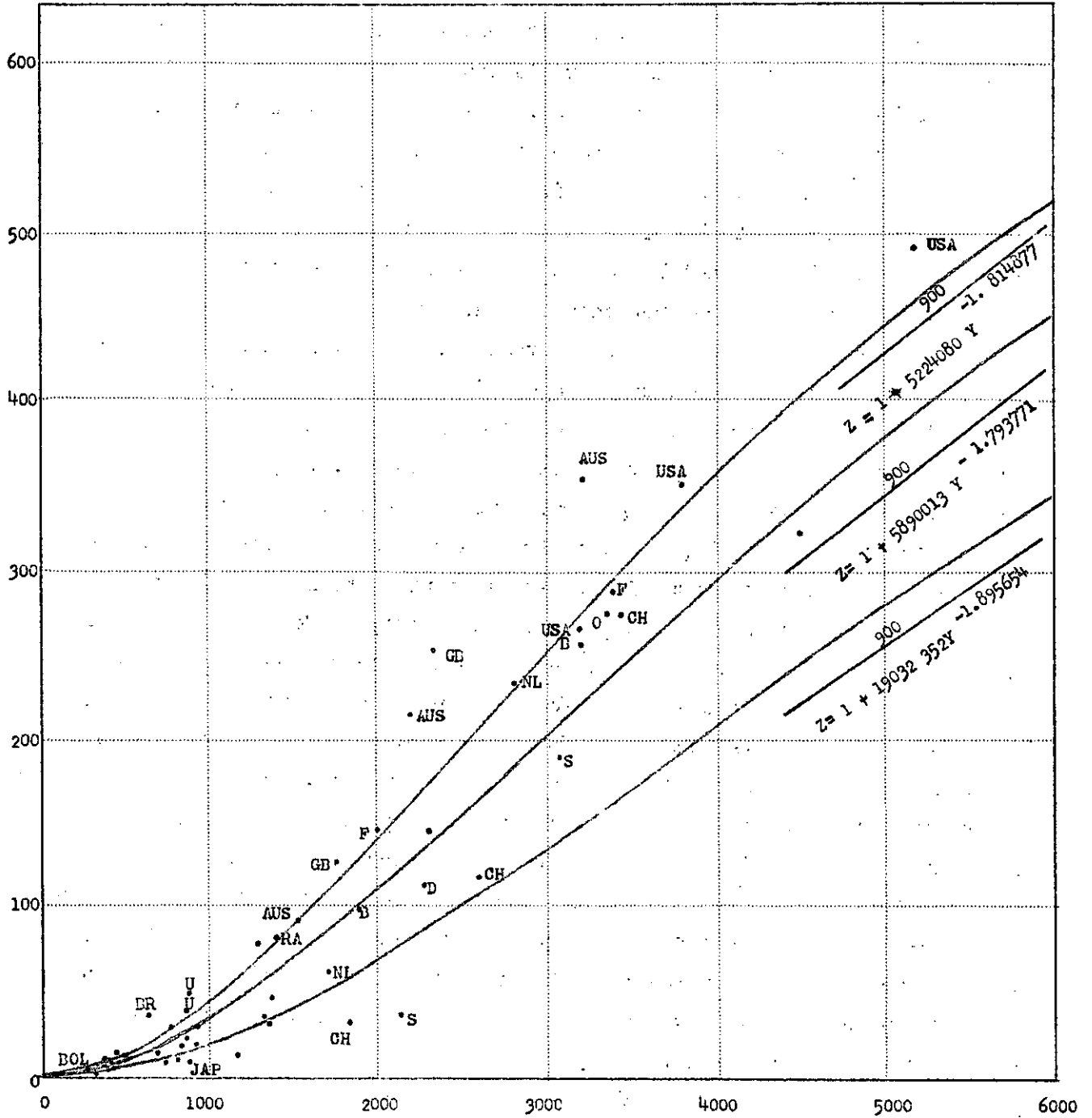
Country	1950-1962		% Est. Growth due to		1962-1974		% Est. Growth due to	
	Observed ownership growth	Estimated ownership growth	Time	In- come	Observed ownership growth	Estimated ownership growth	Time	In- come
RA	10 839	17 579	64	36	49 057	51 541	18	82
BOL	1 291	0 739	186	-86	3 130	2 698	17	83
BR	5 958	4 670	30	70	14 651	24 765	11	89
RCH	2 590	12 822	49	51	14 685	14 225	39	61
CO	4 652	5 328	57	43	9 347	6 271	25	75
EQ	1 200	2 781	55	45	9 199	3 943	18	82
PY	2 082	2 407	91	9	2 856	4 087	43	57
PE	5 323	6 854	34	66	8 930	8 226	29	71
U	20 131	11 110	115	-15	9 017	9 380	87	13
YV	20 433	24 503	54	46	36 954	44 252	26	74
CR	7 374	7 226	38	62	19 251	15 440	15	85
DOM	2 628	3 347	41	59	7 005	8 310	18	82
SAL	6 029	3 912	44	56	4 606	1 898	33	67
GCA	4 892	3 014	68	32	7 385	4 220	18	82
HON	1 843	1 790	77	23	1 726	2 595	47	53
MEX	6 693	11 220	43	57	28 514	22 648	16	84
NIC	3 840	3 214	38	62	6 709	9 974	17	83
USA	86 885	129 153	56	44	183 227	140 613	32	68
AUS	120 438	85 714	34	66	147 539	141 010	23	77
S	152 704	133 187	34	66	194 116	134 767	26	74
CH	85 854	106 013	35	65	132 644	156 499	32	68
F	111 942	78 023	31	69	183 958	139 574	17	83
GB	81 796	56 911	44	56	86 351	126 104	30	70
SAP	8 851	26 342	11	89	145 030	134 897	6	94
D	99 217	108 402	18	82	156 974	163 720	23	77
NL	48 004	58 777	35	65	143 204	171 416	17	83
B	67 319	66 776	36	64	171 501	156 010	16	84

a/ Cars per 1,000 people.

Figure 2.1

FOR 1950, 1962 AND 1974 CALIBRATED FUNCTIONS GIVING CARS PER 1000 PERSONS FROM GDP PER CAPITA SHOWN TOGETHER WITH DATA POINTS

Cars per 1000 persons



### III. THE EXPECTED GROWTH IN THE LATIN AMERICAN CAR FLEET

The forecasting of the size of the car fleet of Latin America at the present moment is difficult, if not impossible. There is unlikely to be as much growth per annum in the world economy in the years to 2000 as there has been in the years since 1950. However, even supposing future growth rates (income effects) there must be considered the petroleum problem (price effect). Some countries in the Region are already taking steps not just to cut back the use of each car but also the level of car ownership. Brazil is a notable example where credit repayment for car purchases must now be made over only 12 months whilst not long ago one could repay over 24 months and before that 36. Brazil is also attempting to develop its own renewable supplies of liquid fuel energy; one may pay back a loan to buy a car which runs on alcohol over 36 months. But there are doubts about the economic viability of the country to produce large quantities of alcohol in the long run. One may surmise that due to the energy crisis car ownership in Latin America will never attain the levels of today in the central countries unless electric cars become viable and safe and cheap means of providing electrical energy be developed. Even so one wonders whether there would be enough resources of rubber, lead, and other materials (and enough energy for their processing) to go round. On the other hand there is much scope for increasing the energy and materials efficiency of some cars currently made in Latin America. One could obtain two modern cars from the resources tied up in many of the older cars still circulating in countries such as Uruguay, Chile and Argentina.

However it is not likely that the steady reduction in car acquisition and upkeep costs of the period to 1973 continue into the future. Also the movement of Latin America into the kind of lifestyle which depends on the automobile already has occurred and the movement itself can give no further growth in ownership.

Moreover it is even possible that the upward movement in the car ownership curve as witnessed by Figure 2-1 may even be reversed in the future. In these times of so much uncertainty it is impossible to be confident in any assertion that one cares to make. Nevertheless we have

made two alternative projections of car ownership by country in Latin America, for the years 1980, 1990 and 2000. The first set of estimates refer to the (probably optimistic) assumption that the rate of change in the equation parameters from 1962 to 1974 continues into the future. This implies that the evolution of lifestyles, change in car prices, movements in perceptions of operating costs, evolution of the income distribution and so on, all continue to move at the same annual rate as they have done from 1962 to 1974. The second set of estimates deal with the (probably more realistic) case in which the 1974 equation holds good up to the year 2000. The forecasts are reproduced in Table 3-1.

Under the former assumption the European level of car ownership of the mid 1970s would be attained by 2000 in Argentina, Venezuela, Brazil, Costa Rica and Mexico. Were the latter assumption to be the true one such levels would only have been reached by Argentina and Venezuela.

Table 3-1  
ESTIMATED CAR OWNERSHIP PER HEAD<sup>a/</sup> IN SOME LATIN AMERICAN COUNTRIES TO 2000

Country	GDP estimated per head (in US\$ of 1970)			Conservative forecast			"Trend" forecast		
	1980	1990	2000	Z 1980	Z 1990	Z 2000	Z 1980	Z 1990	Z 2000
Argentina	1 473	2 058	2 876	87.451	141.828	219.278	99.315	195.633	291.037
Bolivia	356	495	685	6.616	11.614	20.085	7.581	16.777	37.007
Brazil	799	1 253	1 965	44.793	75.765	133.609	48.980	101.461	217.171
Colombia	669	890	1 185	18.449	31.372	51.414	21.541	46.481	95.410
Costa Rica	949	1 517	2 404	39.969	83.269	162.034	45.645	117.714	265.796
Chile	885	1 028	1 256	22.143	35.276	53.191	26.834	55.248	104.196
Ecuador	535	797	1 180	10.738	23.964	48.205	12.791	36.089	89.994
El Salvador	477	587	722	12.163	17.061	29.873	13.834	24.369	43.465
Guatemala	550	683	849	14.889	21.477	30.806	17.052	31.033	56.605
Honduras	302	311	384	5.944	7.126	8.533	6.660	9.844	14.897
Mexico	1 071	1 480	2 051	41.268	84.259	134.783	48.721	109.196	218.026
Nicaragua	493	631	808	17.037	23.436	32.937	18.817	31.787	56.576
Paraguay	508	689	935	12.441	20.856	34.499	15.249	31.124	64.185
Peru	613	792	1 024	18.684	28.565	43.305	21.361	41.121	78.889
Dominican Republic	528	744	1 050	15.644	26.471	45.086	17.652	37.402	80.656
Uruguay	437	995	1 056	53.479	57.517	61.892	59.137	76.574	101.303
Venezuela	1 533	214	2 991	49.013	155.360	284.579	111.415	210.891	351.357

Notes: GDP per capita forecast derived from GDP projections to 2000 of the Centro de Proyecciones Económicas of CEPAL, using "head" forecasts 1980-2000 rather than high alternatives, and population projections from "Boletín Demográfico", año XI, N° 22 de CELADE.

Z = estimated per 1 000 persons.

a/ Car ownership.



#### IV. SOME MACRO-ECONOMIC CONSEQUENCES OF AUTOMOBILE ACQUISITION AND USAGE IN LATIN AMERICA

In the subsequent chapters of this paper we shall develop arguments which infer that in Latin America automobile usage has various regressive characteristics with regards to the distribution of welfare, i.e., the benefits from the automobile accrue to the richer members of society who, in the accrual of such benefits, inflict costs on society in general, both themselves and the poorer majority of the population, for which they are often not held responsible. Such implications are generally undesirable. However it is possible that there are effects of the private automobile, not directly concerned with the distribution of income, which so stimulate the generation of wealth by the nation that any such undesirable implications be at least partly compensated. We shall consider two of these such economic effects in some detail, these being the effect of the automobile on employment and its impact on the balance of trade of the country.

But, beyond this, there are other ramifications of automobile usage and ownership about which comment should be made, even if lack of the chance to make a detailed investigation prohibits that there be anything better than a conceptual introduction of them.

The automobile has an impact on the financial markets of countries through the need of many potential car owners to borrow money were they to realize their dream of car ownership. In Latin America cars are expensive in comparison with incomes; thus the proportion of car buyers who must resort to borrowing funds is probably higher than in the central countries where prices are usually lower and incomes, on average, higher. The existence of the automobile stimulates demand for financial resources by families; were a family to rule out the possibility of buying a car it would probably increase its purchases of less durable items which would not have such a requirement for financing. The demand for funds would tend to push up interest rates and increase the returns to he who has capital to invest, and raising the total amount invested. Furthermore the demand for finance for car acquisition probably diverts funds from other investments which may have higher (or lower) social priority.

/Increasing ownership

Increasing ownership and, more so, usage of private cars probably generates a greater demand for public spending. Many transportation facilities are constructed in Latin America as a result of, arguably, biased evaluation exercises; others are constructed since the social benefits which would accrue from them exceed their social costs. These schemes are thus socially desirable. But were there to be lesser car usage there would be a lesser demand for infrastructure provided at public expense. Were a family not to buy a car, it may decide to allocate the funds thereby made available to a color television set, an extension to the family home, or a vacation. The color televisions would stimulate the demand for those services which provide color television programs, which services are usually provided by the private sector; the extension to the home would also generally involve construction services provided by the private sector; and the vacation need not require significant intervention from the public authorities. The stimulus that the car probably gives to the activities of the public sector through the linked demand for infrastructure (and also police services, control of license issue, etc., provided at a public expense) is not necessarily either a bad thing nor a good thing. In practice, however, the expansion of the public sector in Latin America has not always been neutral; it may stimulate inflation, and the raising of revenue to finance capital works may be such that economic efficiency suffer.

The generation of wealth may be fostered through the ownership of a car being seen as a goal to be reached even at the cost of working long hours spending the evening hours studying etc. The automobile may be unique in such stimulation of human effort.

1. The impact of the private automobile on employment in Latin America

In a fully employed economy the use of manpower is a cost and not a benefit. The stimulation of an industry intensive in its requirement for labour implies, under such circumstances, that labour must be diverted from the production of other goods and services. The labour cost of the new industry would be the reduction in the value of such other goods and services through the transfer of labour resources to it.

/However, there

However, there is little evidence in the current economic condition of the world that any country genuinely considers employment as a cost in the way that the theory of the fully employed economy would dictate, but rather it is considered that the foregone production due to the establishment of a new industrial activity be small and, moreover, that to be employed is a basic human right. Even in the cases of such fully employed economies as Japan, governments go to considerable lengths to maintain employment in industries (such as shipbuilding) which suffer from reductions in orders by one means or another, maybe subsidized financing, public sector orders, or incentives to build for stock.

In recent years in the United States, Canada and Western Europe governments have gone to considerable lengths both to gain new automotive sector investment, and to maintain such investment as already exists. Specific examples of such involvement include:

(i) A contest between Puerto Rico, Eire and Northern Ireland to be selected as the site of the assembly plant for the DeLorean Car Company. This was "won" at high cost in terms of effective subsidy by Northern Ireland.

(ii) A contest between several United States' states to be chosen as the location of the Volkswagen assembly plant. This was "won" by Pennsylvania through the offer of providing infrastructure, etc.

(iii) A competition between several European countries involving France, Portugal, Austria and maybe others, to be selected as the host nation of a new Ford assembly plant. It had been quoted in the press that such was the desire to be selected as the site for this plant, that the President of France spoke personally with Henry Ford offering grants and loans to the value of 1/4 of the minimum investment cost of a billion US dollars so that the plant be established in the depressed region of Lorraine. (The Ford company decided finally not to construct the envisioned plant.)

(iv) In a like manner to (iii) the Ford company was persuaded to locate a factory for the production of engines for its new world car, the Erika, in Wales only after Mr. Henry Ford spoke with the British Prime Minister.

Behind all of these and other similar competitions, employment was probably the main primer mover (rather than the balance of trade impact, etc.). If such competitions are entered into by the governments of the central countries one would scarcely expect any lesser interest from their counterparts in Latin America, where any opportunity costs through resource diversion would tend to be less. One recent example of a similar contest in Latin America was the competition between the Brazilian states of Rio de Janeiro (Guanabara), São Paulo, and Minas Gerais to be selected by the FIAT company for the center of its Brazilian operations. This contest was won by Minas Gerais, again at great cost in terms of financing, tax advantages, etc.

Thus, there is clear evidence all over the world that, in the case of the automotive sector at least, employment generation is seen as a benefit and not a cost. Even in those few cases where a government has taken steps to reduce the size of the national car production sector, the need to provide employment still enters into the argument. In Chile, for example, arguments were lodged by the proponents of the early 1979 government-sponsored scheme to reduce tariff duties on car imports that the incentive thereby given to car ownership and usage would more than compensate for the reduction in employment in the assembly plants.

The motor vehicle provides employment in various activities, which may be conservatively enumerated as vehicle fabrication, the production of components for such vehicles, the part of more basic industries which input to the latter, selling and aftersales service, and repair and other garage services. Over and above these activities other sectors are dependent on the accessibility afforded by the automobile, such as hotels and supermarkets. Excluding the latter indirectly affected sectors it appears that in the main central countries employment in the activities concerned with motor vehicle production (embracing both cars and other vehicles) involves around 5% of the labour force. In the German FR and Italy the rate exceeds 5 1/2%, whilst in Britain, Spain and the United States the rate is less than 5%. Table 4.1 details the proportion of the labour force of certain central countries engaged in activities directly related to the motor vehicle.

Comparable information for the countries of the Region is not available in a reliable manner. The employment statistics for even the advanced countries of the Region often seem to be affected by under-reporting. However, we have found it possible to synthesize comparable estimates for some countries of the Region by assessing the employment related to the motor vehicle in a selected central country, France, and expressing each component of the total as a ratio of the most appropriate independent variable of which estimates are available for the countries of the Region, for instance vehicle production and fleet size. One commercial vehicle was counted as being equivalent to three cars. The ratios were applied to the independent variables for the Latin American countries considered, the resultant indicated level of employment being calibrated so as to correspond to an estimate available for Brazil by more direct calculations. The calibration involved the modification of the initial estimated level of employment by the ratio of GDP per head in France to GDP head in the country being analysed raised to an exponent, so as to approximately recognize that those countries with lower GDP per head are likely to employ more labour intensive means of production. The resultant estimates are shown also in Table 4-1. It is indicated that in no Latin American country does employment in automotive related activities exceed 4% of the labour force, Brazil having the highest proportion, 3.9%, which is, however, quite close to the equivalents in some central countries, especially those which are at lower stages of development (such as Spain) or are net importers of motor vehicles (such as the United States and United Kingdom). In countries with no local productive capacity the percentage of the labour force engaged in automotive activities is less than one.

The primary matter of interest in the present paper is the private automobile rather than the motor vehicle in general. Thus we have considered two countries for the estimation of the amount of employment attributable to the private car, one with the most developed motor vehicle industry in the Region and the other typical of countries at the opposite extreme which have no local production capability. The choice of countries was determined by the availability of information at the detailed level from employment

/surveys. For

surveys. For each country, by the most appropriate means available, we took each category of employment related with the automobile and split the total employment in the category into the part accounted for by the car and the part accounted for by trucks, buses, etc., though partitioning via ratios, such as the amount of tyre wear attributable to the car to the total amount of tyre wear, of appropriate independent variables which may approximately reflect the corresponding ratios of employment. Finally, there had to be considerable adjustments to the total amounts of employment related to the automobile estimated in this way so that total employment by broad sector (-industry, commerce, and services-) as measured in the employment censi be equal to similar estimates from population censi. (It is not known fully why the information from the employment censi should generally be under-reported; probable reasons include the non-coverage of small firms and the informal sector, and the reluctance of companies to disclose information which could be disadvantageous to them.) Finally some hitherto excluded categories of employment were added in.<sup>1/</sup> It was estimated in this manner that in Brazil in the year 1970, slightly in excess of half of one million persons were employed in activities connected with the private car. This represents some 2% of the economically active population of Brazil in this year. The procedure was simplified in the case of Guatemala, for which country it was estimated that as little as 0,83% of the economically active population was engaged in activities connected with the private car.<sup>2/</sup>

One may conclude that in few cases is the contribution to employment of the private automobile in the countries of the Region so significant that the overall level of economic activity would be markedly affected were, for any reason, the use of the automobile to be restricted in any way.

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<sup>1/</sup> Certain other categories of employment, such as government officials concerned with the private car, and highway police, were still excluded from the estimates, which are thus conservative.

<sup>2/</sup> Note that this estimate is not comparable with that shown in table 4.1 which is anyway only a rough estimate; for instance the estimate quoted on this page includes employment in a part of the hotel sector.

Governments could invoke policies to transfer at least part of such employment to other activities if, for any reason, there should be a cutback in employment in activities connected with the private automobile. Nevertheless, the employment offered by the private automobile in Latin America does perform an undeniable economic and social function. Although the assembly of vehicles themselves is capital intensive, especially when production is on the scale of Brazil, and even Argentina, there are many subsidiary activities which enable the wealth of the car owner to generate employment to those less fortunate. At the lowest level the car gives some income to persons who park, mind, and wash cars, which activities have disappeared from the central countries (if they ever existed in the first place) whilst service stations, maintenance and repair garages, hotels, etc., all provide employment opportunities and often have further social value in the training afforded to the workers so occupied in technical and other operations which contribute to economic development.

On the other hand the employment generated by the automobile may have upsetting social consequences, which may have economic ramifications. The employees of assembly plants often receive very high wages by the standards of similarly skilled workers in other activities. In Brazil in 1970 the mean wage of those employed in the fabrication of road motor vehicles was more than double that in the industrial sector generally, and almost four times as much as the mean in the commercial sector. Increasingly the employees of such plants are using their bargaining power to extract from their foreign controlled employers considerable wage increases made possible, in some cases, by the good profits that their employers may make from the protected industrial activity in which they operate. The industrial unrest thereby engendered may raise wage levels generally in other engineering industries, and indeed other sectors, which could raise wages above their marginal revenue product, thereby possibly lowering the total volume of employment, and value of production.

2. The impact of the private automobile on the balance of trade in Latin America

Considerations of foreign exchange were influential in the decisions made by certain countries of the Region to initiate the total production of motor vehicles.<sup>1/</sup> In Brazil, for example, the heavy drain that the importation of motor vehicles was having on the trade balance of the country, and its contribution to the exhaustion of reserves of foreign exchange by the beginning of the nineteen fifties, were the prime movers behind the first steps toward the development of large scale automotive production. On the other hand, recently, in some countries of the Region, (Chile and Argentina), the artificial development of motor vehicle assembly has been to some extent associated with economic models accredited as having adverse effects on trading performance through the diversion of human and capital resources away from those activities in which the country has comparative advantages.

As in the case of employment, the estimation of the true impact of the automobile on the balance of trade (let alone the more complicated problem of the balance of payments) is impossible without the availability of a calibrated inter-sectorial model of the economy, together with detailed information about the structure of consumer spending and automobile industry cost structure. Some of the impacts which could hardly be estimated in any other way include:

(i) Car usage either causes a fall in petroleum exports or a rise in petroleum imports.

(ii) The requirement of gasoline by automobile users, in most countries, entails that more revenue be transferred to the government through sales-type taxes than would be the case were the resources of the consumer to be spent on other goods and services (which usually bear lower rates of taxation). The government would only by coincidence use the funds transferred to it to affect the trade balance in the same way as would have occurred were they to remain in private hands.

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<sup>1/</sup> In other countries, other factors may have been at least equally important, such as economic nationalism.



(iii) Car operation consumes parts, which may be imported, or may consume resources that might otherwise be devoted to exportation.

(iv) Car acquisition either implies that the vehicle be imported or that parts would have to be imported and assembled with resources that could otherwise have been partially assigned to exportation.

(v) Were there to be a local vehicle production industry it may be feasible to generate exports at low marginal costs.

(vi) Car assembly operations, as we have seen above, tend to pay high wages, and be instrumental in spreading higher wages through to a privileged sub-section of the labour force. This has effects on the overall propensity to import.

We have been unable to even consider the use of models of the required degree of sophistication that these and other relevant impacts be internalized in our calculation. But we have made some tentative moves towards the estimation of the proportion of both imports and exports of certain countries which may be attributed to the private car. The results are necessarily not a fair reflection of the overall impact of the automobile on the balance of trade.

The estimation of the part of the total import bill due to the private automobile is the more complicated. The basic procedure was firstly to tabulate from the annuals of international trade the total amounts of those imports in categories which may be assignable in part to the private car. Then these totals were partitioned into the part accounted for by the private car and the part accounted for by other vehicle types, and other, non-automotive, uses. In the case of imports of crude petroleum, for instance, this partitioning routine involved the estimation of the proportion of crude refined into gasoline, and into the various other products derived from each barrel of petroleum. Each product was assigned an international market value and the proportion of the total import bill due to gasoline was calculated as the market value of the fraction refined into gasoline relative to the total market value of other refined products. Finally there had to be an adjustment to reflect that private cars consume only a proportion of gasoline, some being used for taxis, some being exported, etc. The calculations were performed for

/Brazil and

Brazil and Nicaragua, using the year 1976 in both cases. It was found that in the case of Brazil 9.62% of the import bill was attributable to the private automobile. In the case of Nicaragua the percentage was 5.12. (See table 4.2.)

More than 75% of the estimated share in the case of Brazil was due to gasoline, with the only other category of any significance being parts for vehicle construction, or upkeep. Brazil imported no cars in 1976 (except a few to the higher diplomatic ranks and to manufacturers for testing purposes) and only about 2 1/2% of the value of the typical car was imported.<sup>1/</sup> Brazil has insufficient petroleum for its needs, having to import something over 80% of consumption; were the calculations to have been repeated for, say, Argentina, the proportion estimated would have been less on account of the ability of Argentina to cover most of its petroleum consumption from national supplies. (Thus it would have been inferred that the car has a lesser impact on the Argentinian trade balance than really is the case, since non-consumed petroleum is exportable.) In the case of Nicaragua, less than 30% of the proportion of all imports due to the private car were attributed to gasoline imports. The major component, some 55%, was due to imports of made-up vehicles. The parts share was lower than in Brazil whilst the tires and tubes (plus raw materials for their fabrication) was double that in Brazil. The results are shown on Table 4-2.

For Brazil in the same year Table 4-4 shows that only 1.4% of all exports were from the automobile production sector, although the proportion may have increased slightly since.<sup>2/</sup> Brazil exports considerable quantities of gasoline which were not included in the calculations. The volumes exported are a function of the residual not consumed within the country from the refining fraction accounted for by gasoline; were there to be less car usage in Brazil the difference between the amount of petroleum

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<sup>1/</sup> However, this 2 1/2% would not reflect imports of basic inputs such as energy, copper, and designs.

<sup>2/</sup> In 1978 Brazil was exporting as much as 10% of its car production.

which must be imported for diesel oil, fuel oil, etc., would leave an even greater volume of spare gasoline left over. In the case of Nicaragua, one is not able to assign any exports to the private automobile.

Brazil, Argentina and Mexico are the only countries in the Region which source a noticeable proportion of their exports from the automotive sector. Of these three, it is probable that the relative importance of the sector as an exporter has passed its peak in Argentina. In the future, the countries of the Andean Pact are likely to export considerable quantities of vehicles and parts for vehicles to one another as the integrated automotive sector of this economic grouping assumes a tangible form.

Table 4-3 shows, for some Latin American countries, import and export trade in (a) cars and (b) motor vehicle (including trucks and buses) parts as proportions of their total trade, from official trade returns. From this table certain general conclusions may be drawn:

(i) Imports of made-up cars tend not to be of great significance even in the cases of the smaller countries which have no productive capacity. Only in the case of Venezuela did imported cars exceed 5% of the total import bill; this country also assembled considerable quantities of cars.

(ii) Imports of parts for motor vehicles are usually less important than imports of made-up cars except in the cases of those countries which have highly protected local manufacturing capability. In the case of Mexico, in contrast to Brazil and Argentina, the national components industry is not as protected as the assembly operations; hence Mexico imports large quantities of parts for locally produced vehicles.

(iii) Only Brazil and, to a lesser extent, Argentina, are significant exporters of cars, although some other countries with local assembly operations have developed an export trade in components, especially in the cases of those countries, such as Chile, which have complementation agreements in the sector.

Thus even in the case of Brazil the significance of the automotive production sector as an exporter is not fundamental although automotive sector exports from Brazil have recently been expanding considerably. The development of the automobile manufacturing industry in Latin America has

/been essentially

been essentially to substitute for imports, rather than to generate exports. In this respect the industry in the Region differs from those of some countries in Asia, such as Japan and Korea, and also from those of the central countries, where on occasion, whole car plants have been set up (or maintained) with the export market in mind, for instance DeLorean in Northern Ireland, Ferrari in Italy, and Lotus in England. Only recently has the industry of Brazil become noticeably export oriented, to some degree as a result of the diminished internal growth prospects due to the energy crisis. Government persuasion has also been important.

Those countries with no local productive capacity tend to restrict their imports of cars, through varying combinations of lack of buying power and high import duties. The import trade in motor vehicles and parts is rarely significant; the two exceptions to this general rule are Venezuela, where local buying power exacts appreciable quantities of car imports although the country possesses a local industry which enjoys considerable protection, and Mexico, where the stimulation of a vehicle production capacity has not gone hand-in-hand with a similarly determined effort to foster the local production of components. (Mexico, by pursuing this policy has been able to enjoy a cost structure considerably lower than would otherwise be the case, and has, since 1977, been employed as the source of Volkswagen Beetle cars for export to Europe in preference to Brazil, where local content rules are much stricter. However, Mexico's policy has implied large scale imports of parts, representing a considerable drain on the foreign exchange earnings of the country.)

One may conclude that countries are well able to manage their trade in vehicles and parts, and more especially cars and parts for cars, to minimize unfavourable impacts on the trade balance through the fomentation of a national industry or the restriction of sales, although both of these policies have a cost in terms of the allocation of resources within the country. Some countries notably Chile in recent years have accepted the cost of large quantities of imported cars in order to open up their economies and correct the allocation of national resources. The greater potential threat to the trade balance stems from the appetite for petroleum

of the car fleet. Concern about the balance-of-payments impact from the petroleum importation requirement of the national car fleet would naturally be felt most in a country which has made strident attempts to foster the national automotive sector and which lacks large petroleum reserves. The country which best fits this description in the Region is Brazil. The initial reaction of Brazil to the energy crisis was to raise the price of gasoline and limit its availability in an attempt to restrain car usage without affecting the welfare derived from the car industry, whilst a policy was developed to mix alcohol, from national crops such as sugar cane and manioca, with gasoline up to 20% concentration.

More recently Brazil has seen the need to adopt stronger measures, such as severe limitations on the repayment period for loans used for car purchase, which must be expected to impact upon the rate of car ownership, and hence the output of the local industry. Furthermore Brazil is incentivating the production and usage of car which run on 100% alcohol, rather than a mixture which comprises 80% gasoline.

The true balance of trade impact of the automobile is hidden in those countries of the Region, such as Venezuela, Argentina, Bolivia, Ecuador, Mexico, Peru and Trinidad and Tobago, which are largely self-sufficient, or better than self-sufficient in petroleum. In these countries, the development of a lifestyle base around the conventional private car does not, in the short run, imply that ever more expensive petroleum has to be bought on the world market. There is a tendency to disregard the possibility that petroleum not consumed locally may be exported; for instance certain nations of the Region, such as Bolivia and Venezuela, charge the local consumer of petroleum products prices very much less than those asked of the foreigner. A thorough appraisal of the balance of trade impact of the private automobile in the Region would no doubt conclude that the cost in terms of petroleum imports or foregone exports is high, and may cause the frustration of important features of development programmes through the reduction in the amount of foreign exchange available for capital and other projects and the diversion of scarce national resources to the production of substitute fuels.

3. Conclusions as to the impact of the private automobile on the economic performance of Latin American economies

We are clearly in no position to say anything definitive about the contribution of the automobile on the national income of the countries of the Region. The following are some of the factors pertinent to any attempt to quantify such a contribution:

(i) The energy crisis has markedly raised the economic cost of those lifestyles which revolve around the utilization of the private car, either by diverting foreign exchange resources to petroleum imports and away from other goods and services which may have a greater effect on economic growth, or by consuming potential exports which could have otherwise been traded for imports useful in the development process.

(ii) Governments have had success in restricting the loss of foreign exchange through the importation of cars and parts, but this has necessarily been at the cost of a distortion of the allocation of resources in the economy.

(iii) The employment generated by the private car almost certainly raises the total volume of employment, and also contributes to the development and diffusion of skills. However the high wages paid to assembly plant workers may have the effect of stimulating labour unrest which could result in the diverting away from the country other investment which could have provided employment.

(iv) The stimulus which the automobile imparts to the demand for finance may divert investment from projects of social value which would have raised national income.

(v) The automobile probably increases the level of public sector involvement in the economy, which could, under some circumstances, affect the rate of economic expansion.

(vi) The automobile probably stimulates productivity by acting as a goal, attainable only through earning enough money for the down-payment and monthly repayments.

Table 4-1

COMPARISON OF EMPLOYMENT IN CERTAIN AUTOMOTIVE ACTIVITIES a/  
AS A PERCENTAGE OF THE LABOUR FORCE BETWEEN SELECTED  
LATIN AMERICAN AND OECD COUNTRIES IN  
THE MID-1970s

Country	Percentage of labour force occupied
Brazil	3.98
Argentina	3.01
Mexico	3.28
Chile	1.27
Colombia	0.86
Peru	1.29
Venezuela	1.68
Guatemala	0.54
Bolivia	0.72
Paraguay	0.68
Costa Rica	0.78
Britain	4.39
France	5.23
West Germany	5.70
Italy	5.69
Japan	5.18
Spain	4.71
Sweden	5.29
United States of America	4.29

a/ Motor vehicle and trailer fabrication (excluding motorcycles); components for these activities; basic supply industries; selling and aftersales service; repair and other garage services. The estimates for the OECD countries were derived directly from data presented in "The role of the motor vehicle in modern industrial economies" by the Permanent International Office of Automobile Constructors, Paris, France, 1977, and the United Nations Statistical Yearbook. The estimates for the Latin American nations were synthesized using also data from "Anuario Estadístico de América Latina", CEPAL, 1978, and World Bank Atlas for 1977.

Table 4-2

THE BREAKDOWN BY TYPE OF IMPORTS UTILIZED IN PRIVATE CAR ACQUISITION IN BRAZIL (1977) AND NICARAGUA (1976)

Type of good imported	Percentage of total imports to private car sector	
	Brazil	Nicaragua
Gasoline and other oilbased products. (Gasoline generally imported in the form of crude)	78.07	28.67
Made-up private vehicles	0	55.41
Parts for private vehicles either for construction or upkeep	17.49	8.51
Tires and tubes and raw materials for these products	3.61	7.34
Other products <u>a/</u>	0.83	0.07
<u>Total</u>	<u>100.00</u>	<u>100.00</u>
Total US\$ value of imports <u>b/</u>	US\$ 12 023 x 10 <sup>6</sup>	US\$ 532 136 x 10 <sup>3</sup>
Percentage that imports for private cars are of all imports	9.62	5.12

a/ This percentage, due to the method of calculation which makes the best available use of the available statistical data which data varies in format from one country to the next, has a built in tendency to be higher in the case of Brazil. In the case of Nicaragua, it would not include certain types of equipment imported for gas stations and vehicle retailers and distributors, although these would be counted in the case of Brazil.

b/ The estimates are based on F.O.B. values in the case of Brazil and C.I.F. values in the case of Nicaragua.



Table 4-3

PROPORTION OF ALL IMPORTS AND EXPORTS IN STANDARD INDUSTRIAL  
TRADE CLASSIFICATION CATEGORIES 7321 a/ AND 7328 b/  
FOR SOME LATIN AMERICAN COUNTRIES

Country	% of imports in 7321	% of imports in 7328	% of exports in 7321	% of exports in 7328	Year to which data applies
Argentina	0.00	2.56	1.42	0.41	1976
Bolivia	1.21	1.22	-	-	1972
Brazil	0.00	0.91	0.67	0.70	1977
Chile	0.47	1.06	0.00	0.17	1974
Costa Rica	1.88	0.81	0.00	0.00	1976
Cuba	0.90	2.16	0.00	0.00	1974
Dominican Republic	3.85	?	0.00	0.00	1971
Ecuador	1.02	1.49	0.00	0.00	1974/5
El Salvador	1.17	0.71	0.00	0.00	1975
Guatemala	1.55	1.35	0.00	0.38	1975
Mexico	0.13	10.44	0.01	0.57	1976
Nicaragua	3.41	0.95	0.00	0.00	1976
Peru	0.33	1.21	0.00	0.00	1974
Trinidad and Tobago	2.37	0.50	0.00	0.00	1977
Uruguay	2.22	0.57	0.00	0.50	1976
Venezuela	6.49	1.91	0.00	0.00	1975

a/ Category 7321 shows imports of passenger road vehicles other than buses, and exports of the same.

b/ Category 7328 shows imports of parts for motor vehicles (all types), and exports of the same.

Table 4-4

THE CONTRIBUTION OF THE AUTOMOTIVE SECTOR TO  
THE EXPORTS OF BRAZIL IN 1976

Discrimination <u>a/</u>	Value F.O.B. in US\$ 10 000	Percentage of total exports
Made-up cars and car-type vehicles	29 616.72	0.29
Cars and car-type vehicles in CKD form	78 653.97	0.78
(Parts for motor vehicles)	(55 900.98)	(0.55)
Of which assigned to cars and car-type vehicles	30 801.65	0.30
Tires for cars	4 296.40	0.04
<u>Total of exports from automobile production sector</u>	<u>143 388.74</u>	<u>1.41</u>
<u>Total of all Brazilian exports</u>	<u>10 128 303.42</u>	<u>100.00</u>

Source: Based on statistics from "Brasil-Comercio Exportação".  
Banco do Brasil-CACEX and supplementary information from  
"Quatro Rodas" of december 1978.

a/ In Brazil certain models of what most people would call cars are classified as "Veículos de uso misto", which have a third door of certain dimensions thereby enabling them to be used for the transportation of goods as well as people. Such vehicles qualify for a lower tax rate. Several popular Brazilian "cars" such as the Passat and Brasilia fall into this category.

V. THE HISTORICAL CONTEXT OF URBAN TRANSPORTATION  
IN LATIN AMERICA

1. Introduction: the dominance of the streetcar

In order to understand fully the relationship between the private car and the city, where the car has probably had the most impact on society, it is useful to know something about the evolution of urban transportation in the urban areas of Latin America. Such evolution appears to have shown certain significant differences compared with corresponding developments in the central countries. However the history of Latin American urban transportation is very poorly documented and it is not possible therefore in the present paper to present a full and comprehensive picture of the development of urban transportation in the Region. We must by necessity concentrate on those parts of the Region where the most information is currently readily available, these countries being Brazil and to a lesser extent Argentina and Chile with ancilliary information drawn from elsewhere.

In some cities in the Region horse-drawn omnibus services started soon after their initiation in the developed countries. For instance the first bus service in Recife started in 1841 not too long after Paris (1819) and London (1829). But it appears that the arrival of the omnibus as a significant force on the urban scene occurred much later; São Paulo appears to have made no use of bus services at least until close to the turn of the century. Prior to this time, to travel other than on foot in the city meant hiring a coach by the hour. In the second half of the last century the development of urban transportation focused around what is variously known as the bonde <sup>1/</sup> (Brazil), tranvía (Spanish Latin America), tram (UK) and streetcar (US). These were initially drawn by horses and from 1892 (in Rio de Janeiro) by electricity. Some systems used steam in an intermediate period, such as in Rio de Janeiro and elsewhere.

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<sup>1/</sup> This interesting word apparently derives from the english "bond" sold by a tram company to users to avoid problems caused by lack of small change.

The bondes had an enormous impact on city development in Brazil, even before electrification. They enabled the use of land previously too inaccessible for employment as residential or work areas and thus contributed to the expansion of the city and the raising of its productivity. In Lima too tranvías had the same impact. Tramway systems were not always publically owned even though they ran on tracks lain in the public right-of-way, for instance in São Paulo the Light and Power Company ran a large part of the streetcar service. (The later trolleybus system was generally publically owned however.) Until 1930 streetcars had a virtual monopoly of transportation within the city of São Paulo. In the 1920s streetcars accounted for about 80% of the (non-walk) person trips made in the city of Rio de Janeiro. In Lima Las Empresas Eléctricas Asociadas reaped large profits from their monopolistic situation.

Motor buses did not arrive on a significant scale in Rio de Janeiro nor São Paulo until the decade of the nineteen twenties, very much after their introduction in the cities of the central countries (but earlier than in Argentina 1/). For instance the first motor bus services appeared in London around 1904 and by 1914 this city was densely threaded by bus services all motor powered (gasoline, steam, or petrol-electric). The arrival of the motor bus presented a threat to the tramway operators whose vehicles were inherently less flexible in their operation. At the same time as the motor bus appeared on the scene, there were the first developments of significant congestion, which clearly held a much greater threat to the operation of trams than of buses. Congestion seemed to have been the reason behind the attempt of a private tramway operator to be allowed to construct a Metro system in São Paulo in 1927. But permission so to do was not granted. Although investment fell off in tramways their usage continued to increase for some time. Surprisingly enough, for instance, ridership on the streetcars of Rio de Janeiro peaked as late as around 1950 in terms of riders, although the share of the system in the overall modal split had started to fall earlier. The Light company in São Paulo

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1/ According to ADEFA statistics until 1934 Argentina imported neither any complete buses nor any chassis for buses.

saw no future in tramway operation and advised the Prefecture of the city that it would not seek the renewal of its contract when it would come up for renewal in 1941. The second world war caused the declaration of a "forza maior" by the authorities and in fact the company continued to operate bondes in the city until 1947. The tramway system then became completely publically owned.

For a while more the authorities of São Paulo continued to invest in upgrading vehicles and even built a prototype of what was intended to be a national tramcar, which however was to remain an only child. Cheap petroleum, the greater rate of technological evolution of the motor bus, the development of congestion and the inflexibility of the tracked right-of-way all contributed to the decline and fall of the tramways in Latin America. The decline was very rapid, and today it scarcely seems possible that only a few decades ago the streetcar was the most important transportation system in many Latin American cities. Figure 5-1 illustrates the typically sharp fall in the fortunes of the streetcar, using the examples of Rio de Janeiro. In Santiago, Chile the tranvía disappeared in 1959, in Lima 1/ in 1965, the last tram ran in Buenos Aires in 1962, whilst in Rio de Janeiro the last bonde (apart from those serving Santa Teresa which still run and are being renovated) ceased to operate in 1964. These dates of termination broadly paralleled those in some central countries. For instance it was in 1952 that London finally abandoned its tramway system. Other English cities followed shortly after. In other central countries, particularly those in continental Europe on either side of the NATO-Warsaw Pact divide streetcars are still popular, as they are in certain other cities such as Boston (USA), Cleveland, Melbourne and San Francisco, although sentiment plays a greater part here than in Europe.

In London in the early nineteen thirties the trolleybus was conceived so as to make use of investments in power generation and transmitting equipment provided initially for the tramway service after the latter had fallen out of favour due to its inflexibility in the rise of motor vehicle

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1/ In their late years at least the tranvías of Lima became a largely intermunicipal carrier operating services such as Lima-Callao.

created congestion. It is probable that similar reasons were behind the introduction of trolleybuses in some of the cities of Latin America. Santiago, Chile, initiated its trolleybus services in 1947, the same year as the trolleybus established itself in São Paulo. Other cities which have had, and sometimes still have, trolleybus services include Valparaíso, Buenos Aires, Mexico, Recife, Belo Horizonte and Rio de Janeiro. The fortune of the trolleybus in Latin America has been varied. In Santiago they fell gradually out of favour to be intermittently resurrected in the later nineteen seventies as a form of non-polluting vehicles compatible with the Metro system. Santiago refurbished existing vehicles during these attempts at resurrection rather than buy new vehicles. Trolleybuses have disappeared from some cities completely, such as Belo Horizonte and Buenos Aires. The trolleybus experiment in Rio de Janeiro lasted only a few years, the buses being converted to run subsequently as diesel powered vehicles. Some cities in Latin America acquired the usable buses from other cities which had abandoned their trolleybus system. This occurred too in the central countries. For instance trolleybuses from other English cities appeared in Bournemouth, one of the last English cities to run trolleybuses and some double-deck trolleybuses from London were bought for subsequent use in several Spanish cities.<sup>1/</sup> In Brazil, Recife acquired buses from Belo Horizonte and elsewhere and was very pleased with them. They were cheaper to operate than diesel buses and the inherent inflexibility of the system was countered by not completely advisable practices such as running trolleybuses both ways along streets that carried traffic only in one direction of other types of vehicles. Recife would have liked to have been able to have purchased new trolleybuses in 1976 but was unable to do so due to the non-availability of production capacity in Brazil (and the limited amount of capacity available elsewhere) and the limitations on importation due to restricted amounts of foreign exchange. Recife resorted to the thorough overhaul of 25-year old buses already on its books. These are recent signs of an even stronger turn in favour of the trolleybus however, particularly, in Brazil, stimulated by the deficiency of this country in petroleum resources.

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<sup>1/</sup> As in the case of Rio de Janeiro, some were later converted to diesel power.

São Paulo, dismayed by the costs of expanding its Metro system is turning to the trolleybus by ordering over one thousand to a new standardized design from a Brazilian manufacturer to run throughout the city partially on reserved lanes. Other Brazilian cities could follow suit.

### 3. The rise of the motor bus

The motor bus was a late arrival 1/ in Latin America but has since caused a revolution in city transportation at least comparable with that brought about by the private car. The first motor bus ran in Rio in 1908 but there was no real impact of the motor bus on Brazil until around 1930. In Argentina no buses at all were imported until 1934. Real progress was made only after the war. From 1945 to 1970 the car fleet increased by a factor of five, but the bus fleet was not far behind at four in the Republic. The rate of growth in bus usage is evidenced for Rio de Janeiro in Figure 2. For some years the available statistics would indicate that the rate of increase in the bus fleet in Buenos Aires exceeded the same for the car fleet. In Lima the first buses, imported second-hand from the United States arrived around 1930. The factors contributing to the growth in the bus fleets of cities in Latin America include the following:

- (i) The replacement of tram and trolleybus fleets in certain cities.
- (ii) The migration of people from rural to urban areas.
- (iii) The growth in city-size rendering walking an increasingly non-viable transportation option.
- (iv) The intervention of the public authorities in placing large orders for buses in some cities, e.g., Santiago, Chile, Caracas, Rio de Janeiro.
- (v) The attractiveness of the bus as a form of investment to the small investor who wishes to personally supervise the productivity of his investment, e.g., owner-drivers in Santiago, Chile, and Buenos Aires.
- (vi) The development of congestion which has the effect of requiring more buses to do the same amount of work.

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1/ Maybe the streetcar companies inhibited the development of bus services through their considerable political and economic influence.

(vii) The stimulus given by local manufacture of complete buses, in Brazil, Argentina and Mexico, and bodies, in almost all countries, including, for example, Bolivia.

The form of operation of bus fleets varies widely from one city to another. In Buenos Aires individual owner-operators predominate leading to the proliferation of medium sized buses able to be operated by one man and almost always well maintained and obviously looked upon with affection by their owners. In Santiago, Chile there are also owner-operated buses, (small sized taxi buses or minibuses), but the system works less well than in Buenos Aires, partially due to the lower per capita income of the city. Buses are smaller and less well maintained than in Buenos Aires and often appear completely decrepit, due, according to the owners, to the low controlled fares set for social reasons by the authorities. Santiago also has fleets of larger buses some privately owned and some owned by the State. These are generally better maintained and more modern but are one-man operated whereas the same type of buses in Brazil, for instance, are operated by a crew of two, with clear advantages from the point of view of the reduction of unemployment and the speed of traffic. In Rio de Janeiro most services are run by private companies with full sized single decker buses, intensively used, and quite well maintained compared with some of other parts of Latin America.<sup>1/</sup> Rio de Janeiro also operates municipality-owned buses, which largely ply the less profitable central routes. In Brasilia, services are operated by private companies, although, as in Rio de Janeiro, and elsewhere, considerable investments have been made on behalf of bus services by the authorities in terminals, etc. In most cities fares are basically independent of distance travelled. In Santiago a flat rate applies to almost all routes whilst in other cities such as Rio de Janeiro the rate varies with the kilometerage of the line. In Caracas there is a very coarse zone fare system in operation in which buses on the longer routes wait at zone boundaries whilst fares are collected from passengers who wish to continue on into the next zone.

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<sup>1/</sup> Maintenance of urban buses is rarely good in Latin America. In some cases such as the publically-owned EMTSA of Caracas, it is bad. Of 220 Mercedes-Benz buses that this entity bought in the end of 1960s only 80 were left in service in 1971.



The physical nature of a bus varies substantially from one within Latin American cities. Many cities have what are generically known as minibuses which are clearly distinguished from regular buses in the minds of citizens. These buses, which are usually but not always smaller in size than regular buses, are often operated by the smaller enterprises or by the individual capitalist. Many such buses are imported fully assembled from abroad, often from companies in the United States such as Wayne or Thomas, whilst many more comprise truck chassis with locally made bodies. There is some trade within Latin America in such vehicles, such as from Mercedes-Benz of Argentina to Santiago, Chile. The larger minibuses may be physically identical to a regular bus the only difference being that the former would be operated privately whilst the latter publically. In some cities a bus which would be called a micro in Santiago or Lima would be known as just a bus, the term micro not being a part of the local vocabulary, such as in Rio de Janeiro or Caracas for instance. The regular bus tends to be more often bought in some scale by a large public or private operator than is the case with the micro and this leads to some standardization within any one company and to a preference for sourcing from a large scale producer of integral buses or from a large scale chassis manufacturer which has an arrangement with an industrialized body producer. In Brazil Mercedes-Benz produces standard designs which are very widely used both within cities and on interurban runs in Brazil, also being exported to other countries in the Region. Mercedes-Benz do Brazil, for instance, exported over 200 buses to Caracas in the mid-1960s, and many to Santiago, Chile in the mid 1970s. Sometimes similar buses are imported for Latin American urban use from Spain, United States, England, Germany or elsewhere. In Brazil, notably in Rio Grande do Sul, and elsewhere there have developed a few companies specialized in the production of high quality bus bodies which are fitted to chassis from national manufacturers such as Scania or Cummins to produce what are probably the highest quality of urban bus produced in Latin America.

The State is gradually tending to play a larger role in bus transportation in Latin America. This is usually through its operating publically run buses but Brazil, for instance, has recently instigated a system of

/financial incentives

financial incentives for private operators to buy new vehicles. Also fares are almost always controlled by the national or local government authority, based upon estimated cost increases. Operators in some cities claim that the increases granted are insufficient to cover the costs of depreciation thereby reducing incentives to buy new vehicles. On the other hand in exceptional cases the operators choose not to take full advantage of the increases allowed by the authorities, in an attempt to maximize profits through stimulating demand, for instance in the case of the *frescos* (-see below-) of Rio de Janeiro. The State is often caught in a difficult situation, trying at the same time to prevent social unrest, which sometimes breaks out in Latin American cities when bus fares are raised, and to maintain service quality by providing operators with financial incentives. (In Rio de Janeiro some operators have become bankrupt due to fare control.) This causes the temptation to allow operators to charge higher fares only on certain services. For instance in Santiago, Chile early in 1979 there were initiated services by quite regular buses, non-air-conditioned and on which standing was permitted as in any other bus, but at double the regular fare. In Rio de Janeiro services by luxury, air conditioned *frescos* commenced in 1975 at a fare of three times the standard rate (on average), although, as mentioned, operators have since opted to cut their per passenger profit margins. In São Paulo there are luxury (although non-air-conditioned) executive services. The danger of such variations, especially those on the Santiago model, is that investment occur only on the premium fare routes leading to intolerable conditions for people unable to take advantage of such services either because they cannot afford to or because they do not want to travel on the axes travelled by such services.

There are features of bus operation in many cities of Latin America which makes bus travel unsafe. In Rio de Janeiro shortages of bus drivers due to low wages 1/ (blamed by the operators on low permitted fares) leads to undesirably long shifts per day which causes tiredness and seems to be

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1/ These have led to strikes recently in Rio de Janeiro and São Paulo.

a cause of buses leaving roads at speed, crashing into other vehicles, etc. Also in Rio de Janeiro buses attract pick-pockets, sometimes armed. Buses in Rio de Janeiro are driven very hard by the standards of the central countries and even by those of São Paulo or Brasilia, but the drivers are skilled. In Santiago, Chile bus drivers appear more dangerous than in Rio both to other road users and to their own passengers. This has roots in, (i) the requirement that the driver both collects fares and issue tickets as well as drive, (ii) the poor mechanical condition of many buses, allegedly due to low controlled fares which make it necessary to run a bus as many hours of the day as possible and the putting-off of maintenance spending as long as possible, (iii) the competition between driver-operators on the same route which causes each driver to attempt to maximize the time between himself and the bus in front so as to increase as much as possible his own revenue.<sup>1/</sup> In Buenos Aires buses are driven much less violently, but even here buses are assigned an "index of danger" of 19 in a recent transportation study for this city compared with 4 for a private car, 2 for a taxi, and 14 for a truck.<sup>2/</sup>

The bus services of the Region are heterogeneous compared with those in the central countries on the basis of the quality of service offered. This is largely a function of the personal income distribution, being more skewed in Latin America. The income distribution affects the variety of qualities of service offered directly and indirectly. Indirectly, as we have pointed out, the authorities sometimes tend to adopt the easy way out (and play down or do not recognize the long run consequences) and

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<sup>1/</sup> When two buses are close together a chase often develops between them in a sometimes violent manner in the consequent attempt by each driver to get in front of the other one.

<sup>2/</sup> Furthermore, over and above the danger of being in a bus or near one from the standpoint of accidents, buses are sometimes significant contaminators of the air. Diesel buses are often not well regulated and emit dirty fumes which are molesting although their danger to health has not been proven. But in Latin America petrol buses are much more common than they are in Europe and even in the United States. These too are often badly regulated. In Santiago, Chile buses are responsible for the exceptional high proportion of 41% of all CO emitted into the air of the city. See section VII.

allow the operation of services at premium fares, although not necessarily of premium quality, as a way of avoiding fare increases for the poorer classes who sometimes spend as much as 25% of their family income (in Brasilia and São Paulo and maybe more so in less prosperous expansive cities) on collective transportation. Directly, the mere existence of categories of persons willing to pay (and able to pay) differing amounts for different qualities of service leads by the market mechanism to the provision of such different qualities.

For instance in Rio de Janeiro there has been a rapid expansion in the past four years of the *fresões* to all parts of the city, generally linking with the center, offering a guaranteed seat (that is if the bus stops - often the bus does not stop since it has no spare seats), air conditioning, ambiental music, reclining seats, free daily new sheets, and fare collection at one's seat by a *rodô-moça*. These buses charge about three times the regular bus fare. They have had considerable success even in attracting persons who once used private cars. In La Paz there are services by mini-buses accomodating about 20 passengers and on which no standing is allowed and for which a premium fare is charged.

But at the same time there exists a tendency for all services to decline towards the common denominator. The situation seems to be instable. For instance in Santiago, Chile there were once "liebres" on the same model as the mini-buses of La Paz. But in hours of high demand passengers were prepared to pay the premium fare even to stand. Although this was contrary to the contract entered into by the operators with the authorities, the drivers were severely tempted by the opportunity to gain the whole amount of the premium fare without incurring one cent of extra cost. After warnings, the authorities reclassified these liebres as regular minibuses allowed to carry standing passengers but at the regular fare (for all passengers). The operator-drivers were at a disadvantage compared with the regular minibuses which were less luxurious (and therefore cheaper) and sometimes larger. The threat that the same might happen in La Paz seems to be restricting the carrying of standing passengers on the premium minibuses of this city to a few on short distances in the reasonable surety that some already seated passengers will disembark

to make way for the admitted standees. The fresções in Rio de Janeiro are required to have operating air-conditioning. But the equipment is intrinsically less reliable than other systems on the bus and rather than lose the services of the bus through the failure of the air-conditioning system operators are apparently increasingly running their vehicles for short periods with no air-conditioning, to the extent that they can get way with. Basically, the fact that it pays to break the rules leads to the ever-present possibility that the premium services descend to the level of the regular buses.

Note that the stratification of services has the effect of reducing the quality of service for he who has no option (through lack of money) but to use it. The fresções in Rio de Janeiro attract passengers from the regular buses, and thus reduce frequencies for the captive users of the regular buses. Also bus companies may direct investment from their regular services to premium services.

#### 4. The collective taxi

A further feature of service differentiation in transportation in the cities of Latin America is the existence, where tolerated by the authorities (sometimes against the official regulations) of vehicles, usually United States small or medium sized sedans (pre-oil crisis dimensions), which ply a route, which may be loosely described as being fixed, picking up and setting down passengers anywhere along it who pay a set fare to the driver. Such vehicles are known as "por-puestos" in Caracas, the "trufi" in La Paz,<sup>1/</sup> the taxi colectivo in Santiago, Chile, the lotação of Brazil, etc. The system may generically be described as the collective taxi. It has considerable variation. In Caracas the system originated in a period after the war when bus transit sunk to an intolerable low.<sup>2/</sup> There are officially recognized por-puestos which ply

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<sup>1/</sup> The inhabitants of La Paz have forgotten the origin and meaning of this interesting term. One may conjecture that it is an abbreviation of "taxi ruta fija".

<sup>2/</sup> The same thing happened at the same time in São Paulo where trucks were temporarily used as buses, as happened in London after the first world war.

fixed routes and others which basically trade as ordinary taxis but the driver of which keeps a set of route destination boards close at hand. Were he to pass by a crowded bus stop with no passenger on board he might stop, find out which is the most popular destination, and load up as a por-puesto displaying his destination accordingly. This practice is illegal but tolerated. Attempts at controlling the system in Caracas and elsewhere not always met with success. The por-puestos of Caracas charge double the bus fare. It is a popular system and in 1971 had a passenger volume 60% of that of the bus system. In La Paz there are genuine fixed route collective taxis and other cabs which have their route determined by the first passenger who hails them whilst empty (or in the process of setting down) whom the driver is prepared to accept. In Rio de Janeiro the system is illegal too but exists on a reduced scale especially out from the center in the evening peak period.

#### 5. Taxi services in the Region

There is sometimes considerable variety amongst the qualities of regular taxi service offered within a city. Taxis are widespread in all Latin American cities and are long established in most. In São Paulo the system was already a part of the scene in 1912, much earlier than the arrival of the motor bus. They are today very visible but are nowhere an important means of conveyance in the quantitative sense. Systems of operation vary from city to city. In some cities, such as Rio de Janeiro, most taxis are owned by large companies which make themselves responsible for maintenance but which hire their cabs out to different drivers on several shifts during the 24-hour period. In Buenos Aires taxis are individually owned and are sometimes operated by persons who have difficulty in finding employment in their preferred occupation. A taxi driver is a kind of "reserve" occupation to some extent. They are legally obliged to operate between certain hours of the day in an attempt by the authorities to provide enough cabs at all times of the day. In Santiago, Chile taxis too are individually owned but are sometimes bought by large associations of owners on a large scale with bank finance and are sold to members of the association over a number of years. As in Buenos Aires some operators

/are unable

are unable to find employment in their chosen field. In some cities, such as Rio de Janeiro, entry into the industry is either difficult or expensive. This protects the existing operators but reduces the convenience of the service in the eyes of the public. Elsewhere entry is sometimes easy; in Santiago, Chile, for instance, where the advantage passes from the operator (who may have a weak geographical knowledge of the city) to the public who uses the system, there even being effective subsidy on entry since to register a taxi is cheaper than to register a private car. In São Paulo (and in some other cities to a lesser degree) there are as many as four different grades of taxi. The cheapest is the VW Beetle with the front passenger seat removed for easier access to the rear seats whilst the highest category includes vehicles such as the Ford LTD and is used effectively as a telephone-hailed limosine service.

#### 6. The importance of suburban railways

Railroads have existed in certain Latin American cities for the transportation of persons within the urban area or around it since the eighteen sixties (in Buenos Aires). Some were constructed specifically as urban or suburban railways whilst other services were provided on stretches of longer distance lines. In terms of numbers of passengers carried, railroads are sometimes significant as a form of urban transportation in Latin America and they are considerably more important in terms of passenger-kilometers. In Rio de Janeiro suburban train travel is more important than in most other cities in the Region. Here in some years the share of rail in the total number of trips made annually has exceeded 20%. Rail travel has much greater importance on certain axes of the city. It is in Buenos Aires that rail suburban travel has attained its maximum importance in Latin America. In the nineteen thirties forty million passengers annually used the steam suburban services from the Plaza Constitución station in Buenos Aires, second in the world after Liverpool Street in London, and there were other stations of major importance too in the city. In 1957 rail transportation peaked in Buenos Aires at 558 million passengers (-these figures exclude the underground railroads of the city-) which probably represented slightly less than 20% of the total number of trips.

/Including the

Including the underground system the railroad total would have been around 875 million passengers, surely not attained anywhere else in the history of the cities of the Region. However it is possible that in the inter-war years the percentage of all mechanized trips in Buenos Aires which were realized by rail could have exceeded the late nineteen fifties proportion of close to 30%.

In Buenos Aires, as well as elsewhere, railroads to some extent created their own clientele by permitting the population of outlying areas. Surface railroad transportation is significant today however in only a handful of Latin American cities and there is wide variation in the type of service offered from place to place. In Rio de Janeiro the service is largely electrified and heavily subsidized to meet the travel needs of the lower income families in the north zone suburbs. Moreover, it has suffered from low investment. In São Paulo the nature of the services conforms in a general way with that in Rio de Janeiro. In Buenos Aires there is a widespread network of suburban rail services to three different gauges and embracing both diesel locomotive and electric set traction. The system runs here too at a financial loss. In Recife there is a reasonably frequent diesel locomotive hauled service to Jaboatão and São Laurenço. In Valparaíso there is an electric service for commuters. In Porto Alegre there are hardly any suburban trains to speak of (-2 per day-), although there are plans to resurrect the service. In Santiago, Chile, there are now no true advertised suburban train services. The general trend with surface rail transportation seems to be to upgrade in the largest cities and elsewhere where there are clear right-of-way or other advantages but to abandon in other places.

#### 7. The fashion for metropolitan railroads

However there has been a recent upsurge of interest in underground rail transit conforming with the worldwide fashion in this form of transportation. Only in one city, Buenos Aires, is there a Metro of long standing.<sup>1/</sup> This was built from 1913 onwards by a mixture of public and

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<sup>1/</sup> The first Metro was in London in 1863, followed by Chicago (1892), Budapest (1896), Glasglow (1897), Paris (1900), Berlin (1902) and New York (1904).



private funds in a technically incompatible but outwardly similar manner and currently forms a widely used network in the inner area of the city. It comprises 34 tunneled kms and serves as a means of transportation for inner movements and for access/egress to/from the main rail terminals. The first extension since the end of the nineteen thirties has recently been approved. Other metro systems are currently partially operational in three other cities of the Region. In Mexico (opened in 1969) there are 16 kilometers in tunnel to the French-inspired rubber tired system. It is envisioned however that further construction will be to the traditional steel-on-steel system. In São Paulo a metro was proposed as long ago as 1927 but the system of today results from a study made in the late nineteen sixties and was opened in 1975 along 17 route kilometers, in both tunnel and elevated sections. The city is somewhat dismayed by its metro due largely to high cost which is 80% borne by the city. (It is noticeable that there is much more enthusiasm for Metros when the bill is covered largely by other than city funds.) One may conclude that the announced expansion of the trolleybus network in São Paulo to some degree be an alternative to expansion of the metro involving very much less capital cost. The Santiago, Chile system was opened in 1973, since extended, and currently forms about 25 kilometers of route on two lines partially in tunnel on the French rubber-on-concrete system. The system is currently being extended but future plans are in debate due to the high cost, very much greater than forecast. Currently revenues cover only two thirds of operational costs without contributing anything to the huge investment outlay and the system is bringing forth criticism from the operators of bus services who obviously have to cover their operating and capital costs.

A metro system was recommended for Rio de Janeiro in 1968 and construction was started a year later. After ten more years there is still only trial operation and the full inauguration of the first phase has been recently put back until 1981 or 1982, lack of funds is causing the laying off of some construction workers of contractors, but the city continues to be severely molested by the construction works. A metro is currently being constructed also in Caracas along the Pro Patria-Petare axis

/of the

of the linear city as a result of late nineteen sixties feasibility study. A similar study was recently prepared for San Salvador. Quito is considering the commissioning of a similar study. Other cities have had realized for them in the past, studies of the feasibility of a rail-based transit system, such as Guadalajara and Brasilia, which have to date come to nothing. One suspects that the fashion for metro systems in Latin America is waning. There have undoubtedly been some bad experiences with such systems in the past although these may not have been anticipated by the city authorities concerned since the foreign consultants' study reports have seemingly painted too rosy a picture of metros from standpoint such as construction costs, the costs of trains, etc. Users of metros sometimes mistake themselves into favouring the mode since they are unaware of how much city and federal tax revenue they are paying for their ride, over and above the fare paid. The current problems of financing the completion of the Rio de Janeiro metro after years of the city being severely disrupted by construction works cannot be endearing the concept to Brazil. The way ahead for Brazil may be evidenced by the São Paulo precedent in buying a large fleet of nationally-built and designed trolleybuses.

The Metro may be visualized as a reaction to the problem based by congestion created by automobile-generated traffic congestion which disrupts the surface transit system. There are other reactions, such as the reservation of lanes on existing streets for buses, but these in the past have not been considered as alternatives (and few currently exist in Latin America) and it is at least arguable that the fashion for metros in the cities of Latin America illustrates the adoption of not wholly appropriate technology recommended on the basis of studies by foreign consultants who seem not to have understood the true overall nature of the problem. Metros and the private car may share the dubious distinction of being the only two technical innovations in urban transportation in Latin America which have ended up costing more than they are worth.

8. The development of car usage in cities

The private car has been present in Latin American cities for almost as long as there have been private cars. There were four cars registered in the city of São Paulo as long ago as 1901. Whilst car ownership was very low, cars gave increased accessibility to a few at little cost to others since enough road space was available. The real impact of the pattern of urban transportation starts when it causes congestion and this occurs when it is still unimportant as a mover of persons. When there are few cars in a city there is no need to restrict their use. In Latin America measures to limit the use of private cars in city centers have only taken place once the problem of congestion became very severe and it even seems that in some cases such restrictions were only imposed after another problem, over and above congestion itself, the energy crisis, or public concern about atmospheric pollution, became apparent. We lack information but suspect that automobile-generated congestion was already significant in some cities before the second world war. It is noted that congestion was starting to affect the efficient operation of the bondes of São Paulo in the nineteen twenties and much of this may have been caused by the private car, although there would have been other causes too, e.g., the cumbersome commercial vehicles of the era. In the nineteen twenties car ownership in Argentina was high by world standards (1930 car ownership per head in Argentina was not attained again until 1959, a somewhat stunning item of information) and therefore it is probable that automobile-generated congestion was important in Buenos Aires in this period.

But the era of explosive growth in the car populations of Latin American cities has come in the post war era. Tables 5-1 and 5-2 illustrate such growth for the cities of Buenos Aires and Rio de Janeiro. Growth in the major cities of other countries in the Region would in most cases have tailed behind that in these two relatively affluent cities. The trend for Rio de Janeiro can be divided into distinct phases. From 1947 to 1952 growth was rapid, as high as 17 1/2% per annum. In this period Brazil was importing cars with foreign exchange reserves accumulated during the war. Then came a period in which the exhaustion of these funds occasioned a policy of restricting non-essential imports such as private cars, which

/policy had

policy had the additional aim of stimulating the development of a national car production industry. Throughout the nineteen fifties growth in the city's car fleet averaged only two to three per cent annually which implies a fall in the number of cars owned per citizen of Rio de Janeiro during this period. From around 1960 the local automobile production industry started to be able to fulfil the pent-up demand for cars. From 1960 to 1970 the growth rate averaged 13% annually. It should be borne in mind that this decade included the progressive transfer of the city's federal administrative and political functions to Brasilia, the 1964 military revolution and three years of economic stagnation to 1966. But in spite of this the size of the city's car fleet grew at high rates. Growth has since continued at even higher rates, although there is probably at present a considerable downturn due to strict controls on the repayment period for loans used to buy cars (-reactions to inflation and the energy crisis-).

In Argentina the cycles in car ownership growth parallel those in Brazil in a general way.

The fifties and sixties in Latin America witnessed to a large extent a certain conviction that cities must adapt themselves to the car rather than the car to the city. Urban freeways were built all over some cities such as Caracas and Rio de Janeiro in an expensive and hopeless attempt to provide a supply of road space to meet the demand for it. The whole city of Brasilia is built around the notion that the private car could be the basic mode of transportation, the city being unsuitable for movement by any other means. In this era there were few attempts to limit car usage even in the most heavily congested parts of cities except by congestion itself. Quite intolerable travel conditions developed. The situation was worse in those cities with no reserved track transit alternative. Where there was no such alternative, the car was still always the quickest (or least slow) mode available, unless one had to park some considerable distance from where one wanted to get to. So the usage of cars grew. Traffic in the peak periods usually moved at very slow speeds with constant interruptions. When a small incident occurred, such as a motor failure or a collision, or when it rained, the entire traffic circulation in large areas of some cities became paralyzed for periods of several hours. Caracas may have been the most extreme example of this.

/In cities

In cities with reserved track transit systems the situation was not quite as bad. In Buenos Aires the subterraneo and the suburban railroads provided alternatives. In this city it is evident that car ownership grew at higher rates than car use. Table 5-3 illustrates this by comparing car ownership with gasoline sales. In Buenos Aires almost all cars use gasoline and almost all of the larger trucks and buses consume diesel. There are reasons other than reduced car usage per car that the two trends depicted should differ but the magnitude of the divergence indicates beyond any shadow of a doubt that unit utilization was declining throughout the period covered. In Santiago, Chile there were only a few train services in the urban area in the nineteen sixties and car ownership then was very much lesser than it was in Buenos Aires. One would have expected therefore that the rate at whilst car utilization was falling per car have been less than in Buenos Aires. This is what one reference actually provides evidence in advising that in the mid sixties in Santiago traffic growth was at the rate of 10% annually compared with 11% for the size of the fleet (and 9% for gasoline sales).

Table 5-3

PROPORTIONATE GROWTH IN GASOLINE CONSUMPTION AND CAR OWNERSHIP  
IN THE CITY OF BUENOS AIRES IN RECENT YEARS

Year	Index gasoline consumption	Index car ownership
1969	100	100
1970	108	117
1971	114	133
1972	114	149
1973	114	164
1974	109	179
1975	96	195
1976	100	207

Source: Asociación de Fábricas de Automotores (de la Argentina).

/It is

It is possible that those who use cars during the peak periods in the cities of Latin America travel faster door-to-door than were there to be no private car use at all. But it may be more likely that the converse be true. It is certainly undeniable that the private car has brought about a deterioration in the travel conditions of those who do not travel by car, but who nonetheless pay taxes to cover the cost of infrastructure installed to bring travel conditions to something like the level they would be at were there to be no private car travel during peak periods. It is a sad fact that the cities of Latin America have tended to attempt to rescue themselves from the burden enforced by peak period car travel by the provision of infrastructure rather than getting to the root of the problem by placing limitations on the use of the car in periods of high demand. Attempts at traffic restraint by the limitation of city center parking are generally quite recent, enforcement is spasmodic, and policies are inconsistent with one authority within the city maybe stimulating car traffic, whilst another is doing the opposite.

Cities continue to try to emulate those of the United States and elsewhere where resources are more widely available for the provision of infrastructure than in Latin America. The employment of foreign consultants has surely done nothing to improve matters. Attempts to impose logical solutions fall on deaf ears. For instance some years ago the World Bank made a loan to Venezuela for an urban highway in Caracas on the condition that a study be realized into the possibility that the city require that the users of congested road space in the city make a payment to reflect the costs they create. The study was duly carried out and reported favourably on a simple scheme by means of which those wishing to enter the city center in the morning peak would have had to have bought a licence so to do. But nothing happened. Instead the city is presently constructing a Metro which will not improve highway speeds as much as the licence scheme would have done and which costs more by a large and as yet unknown factor. There is little doubt that the car has taken over Latin American cities and the attempts which are made to improve conditions often take as given that there should be no forced transfer of persons from the private car into forms of collective transportation. Cars are the sacred cows of Latin America. In this perhaps lies the most significant difference to date between the cities of Latin America and those of the central countries.

Table 5-1

RECENT GROWTH IN THE FLEET OF CARS, BUSES, AND TAXIS IN  
IN BUENOS AIRES (CAPITAL)

Year	# cars	# buses	# taxis <u>a/</u>
1955	100 666	4 605	
1956	104 993	4 762	
1957	110 508	4 421	
1958	121 166	4 513	
1959	137 268	4 527	
1960	151 816	4 697	
1961	149 292	3 179	
1962	161 217	2 949	
1963	58 983	334	
1964	160 533	3 748	
1965			
1966			
1967			
1968	241 314	5 564	23 491
1969	278 809	6 471	24 193
1970	325 147	7 897	24 387
1971	371 625	9 633	24 955
1972	415 143	11 079	25 817
1973	456 882	12 050	27 925
1974	499 062	12 743	29 008
1975	543 305	13 670	30 000
1976	576 821	14 638	30 000

Source: Asociación de fabricas de automotores.

a/ Also included on cars.

Table 5-2

POST WAR GROWTH IN AUTOMOBILE FLEET OF GUANABARA (RIO DE JANEIRO)

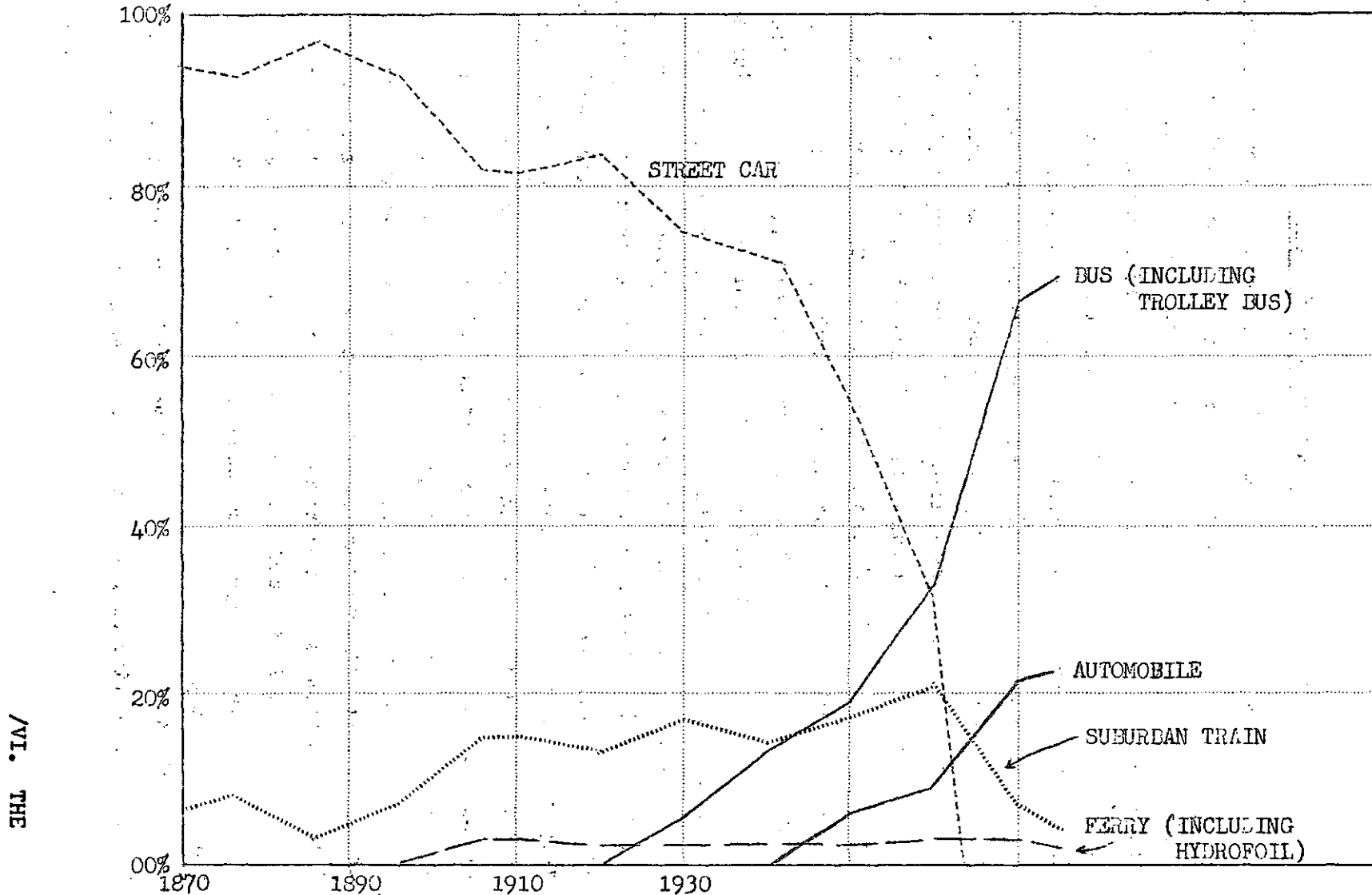
Year	No. cars	Year	No. cars
1947	37 784	1962	103 311
1948	44 400	1963	139 247
1949	47 778	1964	163 980
1950	53 211	1965	193 227
1951	60 413	1966	202 888
1952	67 913	1967	213 174
1953	70 246	1968	225 952
1954	72 579	1969	261 446
1955	74 539	1970	299 806
1956	76 549	1971	
1957	77 491	1972	343 462
1958	80 000	1973	
1959	83 735	1974	374 804
1960	85 182	1975	452 637
1961	94 246	1976	541 304

Sources: Anuario Estadístico do Brasil, various editions.  
Josef Barat - Estructura metropolitana e sistema de transportes;  
estudo do caso do Rio de Janeiro.



Figure 5.1

MODAL SPLIT OF PERSON TRIPS BY MECANIZED MEANS (INCLUDING HORSE - DRAW STREET CARS) IN RUE CITY OF RIO DE JANEIRO 1870 - 1975



Sources: 1) Josef Barat, *op.cit.* 2) Companhia do Metropolitano do Rio de Janeiro. "O Metro do Rio de Janeiro e o futuro sistema integrado de transporte de massa"

## VI. THE SOCIAL CONSEQUENCES OF THE CONCENTRATION OF CAR OWNERSHIP IN LATIN AMERICA

### 1. Concentration by social class

In Latin America, car ownership is highly concentrated by social class. This in turn implies a concentration of cars in the cities of the Region, where they do the most damage to the social fabric. Those who own and use cars, enforce on those who do not inferior transportation services. Thus car ownership and usage in Latin America is a regressive influence in the distribution of the fruits of economic progress.

In the central countries, when the automobile was young, it was only owned by the very rich. As production expanded, scale economies were reaped thereby permitting a lowering of prices. Competition forced such a lowering. Personal incomes grew and became better distributed as the excess pool of unskilled labour was mopped up. Cars became more and more a consumer good for all rather than a plaything for the rich. Nowadays, in the central countries, the car is an everyday necessity, the non-availability of which causes severe social disruptions. This is clearly evidenced by events in the gasoline shortage which started in the United States in the early summer of 1979. Car owners were prepared to spend hours in line for the topping up of their already nearly full gas tanks; they sometimes resorted to the law of the jungle were they to personally consider that they were being unfairly treated in any way. The elasticity of demand for gasoline in the United States over a two year period has been estimated at 0.1. There can be no clearer evidence of the degree to which modern central country society is wrapped around the automobile.

In the central countries, the more affluent members of society can afford more and/or better cars, but everybody who wants a car and who is legally and physically able to drive one, can acquire a 1961 Chevrolet Corvair or a 1962 Austin Mini. Some people do not want a car, especially those living in densely-packed inner areas with good collective transportation and nowhere to park.

Latin America, in regard the level and distribution of car ownership, is quite reflective of the central countries of bygone years. The São Paulo

of 1974 is the Detroit of 1934, or the Coventry of 1954, or the Milano of 1964, or, maybe, the Bogotá of 1984. In Latin America cars are often expensive, incomes are badly distributed, and their mean levels are low. Cars are the preserve of a privileged minority.

The high prices of cars in Latin America are renown. There are few exceptions to this general rule. The countries have either imposed high import duties to raise revenue or to foment the development of a local production capability, with certain exceptions. In Argentina a locally produced Ford Taunus (Cortina) costs in the neighbourhood of the equivalent of US\$ 20,000. In Chile a Volkswagen Brasília costs the equivalent of US\$ 9,000. In Brazil cars are cheaper than in most parts of the Region due to this country having developed an efficient national automotive industry. Thus, for instance, the Volkswagen Passat sells in Brazil for the equivalent of US\$ 5,700 to US\$ 7,500, very much the same as in the United States where the same car, under its americanized name of Dasher, sells at between US\$ 5,500 and US\$ 6,500. In the United Kingdom specific taxes on automobiles push the price of the Passat up to the US\$ 8,000 to US\$ 9,000 equivalent range. However, when expressed as a fraction of the per capita GDP of the country concerned, the price of the Passat is 5.28 in Brazil, 0.81 in the United States, and 1.89 in the United Kingdom.

It is true to some extent that the availability of used cars makes car ownership less inaccessible for many Latin Americans than it would otherwise be. However most countries do not allow the import of used cars which would otherwise make car ownership possible for many people of the Region who now cannot aspire to such things. The form of the income distribution in most Latin American countries would imply that initial depreciation rates on cars be quite high, since there would be comparatively few people in the income range such that they just cannot manage to afford a new car but could run to a clean used vehicle. The usual supposition is that depreciation rates of car prices in Latin America are low by the standards of the central countries, but analysis does not also prove this. A Passat of four or five years of age seems to be worth a slightly higher proportion of the price of the equivalent new car in the United Kingdom

/than in

than in Brazil, although the rate of physical deterioration would no doubt be greater in Brazil (due to higher accident rates, inferior road surfaces, etc.). Vehicles stay in circulation in Latin America for many more years than in the central countries. Pre-war cars are still a regular sight on the roads of countries such as Chile, Argentina and Uruguay. Cars take very many years in Latin America before they are valued as nothing better than scrap, due to the high prices of new cars and the preparedness of many persons to devote considerable time and energy to keeping operative elderly vehicles, even if only for occasional use at weekends. In this manner it is true that the availability of used cars does permit that car ownership filter down to some degree through the social classes.

It is of passing interest to consider the impact of the skewed income distribution on the total amount of car ownership. At very low average income levels, a switching of income from the mean person to the richer individual could enable the latter to buy a car whereas he could not so have done were he not to have benefited from the transfer. Thus at the income levels of Bolivia, or Honduras, the fact that the distribution of incomes be skewed probably tends to raise overall car ownership. However were income transferred from the mean person to the richer individual at a higher average income level this might imply that funds be switched from somebody with a high propensity to buy a car to somebody with a lower propensity, due to a high probability of already owning one. Thus the skewed income distribution of Brazil or Chile may tend to depress car ownership.

However, regardless of the actual overall level of car ownership, in Latin America such ownership is highly concentrated by social class, or income group, due to the skewness of the income distribution and the often high dollar equivalent prices of cars. In many Latin American countries, only the more affluent families own cars. Ownership of a reasonable modern car is largely a synonym for being a privileged member of society. We present some numeric evidence of the extent to which car ownership is concentrated by social class by example of São Paulo, in Table 6-2. Note that in the city of São Paulo car prices are very low by Latin American

standards, average income levels are high, and their distribution is probably less skewed than in many other parts of the Region, due to the relative shortage of some qualities of unskilled labour. Hence one would tend to expect that car ownership in São Paulo be less concentrated in the hands of the privileged classes relative to the situation in other parts of the Region. But even so it is a quite sobering realization that in São Paulo (in 1977), of all cars registered in the city, 18.1% are second cars (in one family), and 3.6% are third cars. There are more second and third cars in São Paulo than cars of any kind in the possession of the less affluent 65% of families.

## 2. Concentration by location

It is generally recognized that in Latin America the higher family incomes tend to be much more highly correlated with demographic density than in the central countries. In the Region, agriculture is still well within the phase that it was in the United Kingdom in the midst of the past century, or continental Europe in the earlier years of the present century, when advances in labour productivity were rendering available large quantities of unskilled labour from farms, which depressed rural incomes, at the same time that demand for labour was increasing in the cities, thereby raising urban incomes. We present in table 6-1 some evidence of the disparity in family spending between selected rural and other parts of Brazil, and we show that the disparity in spending is reflected in spending on private transportation.

In the central countries it is common to find that car ownership be higher in rural states and countries than in urban boroughs and wards. There is generally a lesser income disparity between the urban and rural areas in the central countries (compared with the countries of the Region) and car ownership tends to show itself to be more responsive to the fact that the utility of a car is greater in rural areas, due to the lower level of accessibility in general, and especially accessibility via collective transportation. But in the countries of the Region the income disparity between the rural and urban areas generally dominates the effect of relative accessibility so that car ownership per capita is much higher in the more

/urbanized areas

urbanized areas. Figure 6-1 provides evidence of this for the states and territories of Brazil. It illustrates the positive correlation between the percentage urbanization of the unit of the federation and the car ownership rate. The correlation is not perfect; it cannot be since it is the joint product of a less than perfect correlation between the degree of urbanization and income per head and a further imperfect association between income levels and car ownership levels. Three states stand out from the overall trend, these being Paraná, Santa Catarina and Rio Grande do Sul. These states are of relative european aspect with rural sectors somewhat on the style of the central countries, being quite efficient and affluent, by the standards of the northeast states for instance. Hence the rural-urban income disparity in these three states is less pronounced than elsewhere, and the relative accessibility factor may come more into play.

As we shall go on to discuss, the propensity in Latin America that car ownership be concentrated in cities rather than in rural areas implies that such ownership be located where it does the most social harm.

In the central countries too it is a general feature of car ownership patterns that within cities (as well as between cities and rural areas) ownership be at higher levels in those parts less densely populated, due to the preference for the more affluent to live in greener districts on the outskirts of town, or beyond, and to the tendency for car ownership to be lower in those inner districts where collective transportation is good and space to park a car is hard to come by. The same trait is not always observable in Latin America, especially in those cities which do not possess reserved track collective transportation systems of reasonable quality between the outlying suburbs and the central area. Thus, in the case of Rio de Janeiro, to mention a somewhat extreme example, although the city possesses a quite extensive suburban rail network between the central area and the north zone, this is not up to the quality that appeals to the higher income families. In Rio de Janeiro certain high density inner suburbs, notably Copacabana but also others such as Botafogo, Flamengo, and Ipanema, have high rates of car ownership whereas ownership rates are probably less in certain northern suburbs, such as Deodoro and Novo Iguaçu,

/where densities

where densities are lower. Thus, even at the micro-level within cities, in Latin America car ownership may be concentrated in those densely-packed areas where it does the most social harm. It is reputed that Copacabana has the highest density of car ownership per unit area of any comparable district in the world, and it is clear from mere observation that the social costs of such dense concentration are very high.

It should be borne in mind however that the probable positive correlation between car ownership rates and demographic densities of Rio de Janeiro is an extreme case and not necessarily typical, although we lack sufficient data to prove the point one way or another. In Buenos Aires the quality of the rail services is such that the more affluent are prepared to use them and the concentration of car ownership in the denser districts does not occur; the highest rate of car ownership is in the affluent and sparsely populated Retiro suburb. Even in Santiago, Chile, which has no rail network which links the inner and outer areas of the city, car ownership is not obviously centered in the denser zones. Nevertheless it is probably true that in Latin America there is a stronger propensity that car ownership be concentrated in those zones with higher demographic densities than is the case in the cities of the central countries.

### 3. Transportation demand by social class

The concentration of car ownership is, thankfully, less than the extent to which car usage, in terms of kilometers travelled, is concentrated. For instance, in 1976, the ratio of gasoline sales to cars registered in the Federal Capital of Argentina was 1.48 ( $m^3$ ) whilst in rural Misiones State it was 4.08. It is probable that some car usage in the Capital was performed with gasoline purchased elsewhere, and it is probable that some of the gasoline sold in Misiones was bought by Brazilians taking advantage of cheaper prices in Argentina, but the general conclusion that cars registered in outlying areas travel more than those registered in cities is undoubtedly true.

However, the same conclusion cannot be drawn were one to consider travel consumption in terms of number of trips made rather than in terms

of number of kilometers traversed. Table 6-3 provides evidence that the number of trips made is positively correlated with family income. Also it is boosted by car ownership, independently of the income of the family. It is shown too that trip rates are higher in the outlying parts of cities than in the more central districts, although some of the trips originating in the former would doubtless be made to the inner areas, especially commuting trips. Thus the table provides us with some evidence that the more affluent place the higher demands on the urban transportation system since trip-making responds positively with income, and trip-making is stimulated by the ownership of a car and car ownership is concentrated amongst the more affluent.

Further evidence that the more affluent place higher demands on the transportation system, which is largely provided at public expense, is given by figure 6-2. This shows, once again, using the case of São Paulo rather than Buenos Aires as in table 6-3, that trip-making correlated positively with family income. Furthermore, it illustrates that the richer make a higher relative and absolute number of their trips by car. The car is recognized as being a much greater consumer of road space than a bus, since it carries on average only 1 1/2 persons against maybe twenty times this number in the case of a bus, whilst traffic engineering studies have estimated that the impact of one bus on the traffic stream is the equivalent of only three cars. Furthermore cars are more consumptive of expensive parking space than collective transportation vehicles. Thus we have another reason, the third, to back our claim that the rich make disproportionate use of publically provided urban road space, i.e., that the absolute and relative number of trips made by car increases with income.

A fourth reason is that it appears that the rich make more of their trips in those hours when there is the highest ratio of demand for supply of road space, i.e., the peak hours. That this be so is nor conclusively proven, but it is a deduction which one makes from the most comprehensive trip-pattern data available to us, for the city of São Paulo, and it is seemingly backed up by observation in other cities. It may be a phenomenon unique to Latin America. Table 6-4 shows trip rates in São Paulo by journey purpose and by family income. Of the journey purposes listed those which

/tend to



tend to be concentrated most in the peak periods are work trips, trips for education, and trips to serve passengers. These trips account for most of the increment in the number of trips made as family income increases. On the other hand trips for other purposes vary quite little with income. The rich tend to make more intensive shopping trips by car to the supermarket rather than frequent journeys on foot or by bus to the neighbourhood grocery store. In Latin America the rich are able to reduce the number of personal business trips they make since they are able to hire the services of despachantes and also can substitute their home telephones for physical movement. The richer are more able to avoid trips for health reasons by staying more healthy in the first place, and also the very rich can better afford treatment in their own homes. Even trips for recreation and visiting do not respond very much to income, for reasons that can only be suggested. In Latin America such trips are generally more a way of life than in most central countries. It is possible that growing affluence changes people from their traditional behaviour patterns towards the lifestyles of the central countries.

Thus, to sum up, there are the following reasons why the rich place higher demands on publically provided urban road space than the poorer in Latin America:

- (i) Trip-making correlates positively with income.
- (ii) Trip-making is stimulated by the availability of a car at any income level.
- (iii) The rich make more of their trips by the private car.
- (iv) The rich seem to concentrate their trips more in the peak periods.

#### 4. Impact on distribution of real income

It is possible that the extra demands on the transportation system made by the rich are worth the social costs expended to cater for them. But one doubts whether many of such demands be worthwhile. Certainly, the prices paid by the affluent for the trips they make would often not cover the social costs of providing them. Thus the affluent weigh the benefits they would receive through travelling with only some of the costs involved. Therefore they would tend to make some trips which cost society in general more than the trips are worth.

/There are

There are several reasons why trips made in urban areas, and especially those made at peak periods and by automobile, are likely to cost society more than the price perceived by the trips maker. They include:

(i) Intensive use of urban roads leads to demands (justified or not) for the provision of more infrastructure at public expense, either more roads or metros. These would be often paid for through general taxation revenue rather than by those who use them.

(ii) The trip would often generate noise and atmospheric pollution which affects those walking along the streets concerned and living or working in the neighbourhood, which persons are not compensated for the costs forced upon them by those who are responsible.

(iii) When a car or other vehicle enters a congested traffic stream it slows down the vehicles already there, thus forcing extra delay and operational costs on the latter. The driver of the marginal vehicle would necessarily pay the costs of his own time and his own operating costs but he would not generally be called upon to cover the costs which he forces on others. Many of these others may be bus travellers unable to afford the luxury of private car transportation but who nevertheless are adversely affected by the actions of the car owner.

(iv) It has been found that car drivers rarely know their true marginal car operating costs, since they have no idea of how much maintenance cost nor tyre wear, etc., follows from each kilometer travelled. Thus, depending on the taxation on car usage, a driver can even make trips which really cost him more than the benefit he derives from realizing them. (On the other hand, bus fares are quite obvious and well perceived.)

In this chapter we wish to concentrate mainly on item (iii) in the above listing. In so doing it should be stressed that we are underestimating the extent to which the travel behaviour of the more affluent adversely affects society in general, and the less affluent classes in particular.

Note that in rural areas the costs attributable to car travel are rarely more than those paid by the trip maker himself. Where there is no congestion the introduction of one more vehicle to the traffic stream does not interact with other vehicles already there. Furthermore, even were one to choose to assign the costs of the highway used to the various users,

/the relatively

the relatively light and inoffensive car should receive very little of the total costs allocated. Only in exceptional cases, such as on Sunday evening approaching Caracas from the west where considerable congestion develops, does rural car travel cost society any more than the amount paid by the trip maker.

The costs imposed by urban car travel vary markedly from place to place within any one city and from one time of day to another. The extent to which one marginal car slows down the traffic stream varies with the relationship between speeds and flow for the road concerned and the volume of traffic. The interaction between speeds and flows is greatest on narrow roads with friction from frequent intersections and parked vehicles. The highest costs forced upon the other users of the highway are thus on city center streets and also, even more so, on roads such as radial routes in peak periods when capacity is utilized to and beyond design limits. Generally when a road is operating at very close to its physical limiting capacity the social costs associated with the marginal vehicle can be very high indeed. For Caracas it has been estimated that the total cost of accomodating one extra vehicle (including both the private costs naturally borne by the driver and the social costs forced upon others, both car occupants and the collective transportation users) on a three lane road is 0.75 bolivares per kilometer were the traffic volume to be 1,750 units of one passenger car per hour;<sup>1/</sup> were the volume to be 2,000 car units the extra costs would be Bs. 1.6 per km; and were the volume to be 2,250 car units the extra costs would be as high as Bs. 4.8 per kilometer, all in 1971 prices.

Taking once again the case of Caracas in 1971, figure 6-3 shows the variation throughout the hours of the day both in the private cost of travelling on an inner area circuit (per km), which cost is borne by the trip maker, and in the social cost, which cost is forced by the trip maker onto others. Note that, in the case of such a circuit, the private costs hardly vary at all throughout the day, whilst the social costs vary enormously. The trip maker would indeed have little incentive to travel at those times of the day when he costs others less.

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<sup>1/</sup> Counting a bus as being equal to three car equivalents, etc.

The information for Caracas is taken from the findings of a study realized some years ago which sought to determine the feasibility for this city of systems whereby the driver of the car, and other vehicles, would be made to cover the costs of the congestion he causes, i.e., be forced to pay the whole social costs of the congestion he creates. The study developed a simple scheme which would have required drivers to have bought a licence to be allowed to enter the central area of the city in the morning peak period.<sup>1/</sup> The price of the licence would be determined by the costs forced upon other road users by the marginal car. Such schemes, known generically as "road pricing" in the literature are well known amongst transportation economists. But it can be argued that they do not go far enough.

The private car is essentially the intruder to the urban transportation scene, as detailed in chapter V. It is the polluter. Those "polluted against" are the users of collective transportation. Road pricing schemes can only be argued to strictly adhere to the "polluter-pays-principle" should the revenues collected from the polluters be circulated back to those polluted against to fully compensate them for their inconvenience. Some items of road pricing literature claim that such revenues should be spent on expanding road capacity, for the benefit of those paying the fees rather than those, the users of collective transportation, on whose account the fees are partially being paid. Furthermore, the principle of Pareto would require that the introduction of car traffic into the urban scene be justified only were the users of cars able to compensate, and actually make payments to those rendered worse off. Thus one should conclude that road pricing schemes such as that proposed for Caracas only be sufficient were the toll revenues in reality used to compensate those disadvantaged, to the extent necessary, with any amount left over being left to subsequent analysis as to what should be done with it.

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<sup>1/</sup> The scheme was not implemented in Caracas, due to political and other difficulties. However, the World Bank, which was responsible for the commissioning of the study, has been instrumental in introducing basically the same scheme which was designed for Caracas in Singapore.

The impact which traffic congestion has on cities in respect of those who travel by collective modes is somewhat different in Latin America than in the central countries, largely due to the fact that bus services are rarely operated by the public authorities with certain social objectives in mind, but rather are, for the most part, operated by private companies and individuals (-see section V-) under loose public supervision. Furthermore it is important to stress that the impact of a given slowing down of bus services in a Latin American city may be greater than the equivalent in the central countries since, in the Region, the central country tendency for the less affluent to live closer to the center whilst the richer take advantage of better ambiantal conditions in the periphery is to some extent inverted. The poorer therefore have to travel, in many cases, very long distances from, for instance, where they live to where they work thereby exacerbating the impact of any deterioration in the quality of bus services. Tables 6-5 and 6-6 give some idea of the greater travel times to which the less affluent are subject in São Paulo relative to the more affluent.

It is possible to trace through a certain chain of events which follow from the slowing down of bus services by automobile-generated congestion. First of all, the previous fleet size is unable to deal with the demand for travel by collective transportation within a given time period. The immediate consequence of this is overcrowding, from which follows public clamor for improved services. The private operators are often limited in their ability to provide more buses due to the fact that the fares that they are allowed to charge by the supervisory public authority are tied to changes in operating costs. There may be no provision for the raising of fare levels on account of the desirability of incurring extra capital expenditure to ease the degree of overcrowding in the formulae used. Moreover, in the formulae used by some authorities, the overcrowding may effectively even lead to a reduction in the extent to which cost increases be passed on as fare increases, through the spreading of the extra costs amongst more passengers.

Even were there to be no control of fares by the public authorities, the bus operators would be limited in the extent to which they be able to

/raise fares

raise fares to cover the acquisition of more buses by the extremely low purchasing power of some of their passengers. In Brasilia and São Paulo, for instance, the poorest families may spend 20% of their income on collective transportation, clearly leaving little scope for the elevation of fare levels.

The quantitative significance of the adverse impact of automobile-generated congestion on bus services has not been fully estimated. The study for Caracas referred to earlier considered the effects of charging all car driver trips in the morning peak period a toll of Bs. 3.00, in a situation in which the operation of the Caracas metro line was simulated. From the findings of the study it can be deduced that the size of the bus fleet necessary to carry a given volume of travel would fall by 12% and fares could fall (through lower operating costs) by 6% were 32% of the car trips diverted to other modes of transportation. The latter figure may be considered excessive in relation to the former two, but it should be borne in mind that these 32% of car trips are marginal trips in the sense that they are the ones which derive the least benefit by being made by car in the first place since they are the first to be diverted by the toll. Moreover it is probable that a better relation between benefits to bus passengers and reduction in car trips be achieved by tolling only those trips bound for the central area of the city.

#### 5. Policy Implications

It would seem that to redress the inequities caused by the affluent forcing upon the less affluent worsened travel conditions in the cities of the region, there must be devised schemes whereby car travellers 1/ in the peak be tolled, the revenues thereby gained to be at least partially utilized to compensate the captive collective transportation riders for the

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1/ In general the concept should be expanded to include users of modes other than the car during periods of congestion. For example collective taxis sometimes generate more costs on account of the congestion they create than the value of the services they offer. They should be taxed too. It would probably tend to occur that, per person, the richer would be charged more than the poorer since the richer tend to use those modes of travel which are the more wasteful of road space per person conveyed.

inconvenience that congestion forces upon them. There are a wide variety of schemes which conform to this general pattern. None have seemingly been introduced in Latin America.

Were it to be considered undesirable, from either the political or legal (or other) standpoint to raise revenues from peak hour car travellers, other non-monetary schemes to redress the equilibrium could be substituted. Such alternative could involve the withdrawal of a part of urban road capacity in peak periods from being utilized by cars, so that collective transportation may function at speeds not significantly different from those which would have prevailed were there to have been no inordinate growth in car usage. Relatively passive devices of this nature include the reservation of lanes by buses. More extreme forms than this are not discussed in public, but there may, on occasion, be a very good case to be made out for the complete banning of cars on certain thoroughfares and in all central parts of cities in the peak periods.

No Latin American city has implemented any kind of pricing scheme on car users, and others, in the peak periods, the revenues from which are circulated back to those who are disadvantaged by such usage. The road pricing investigation for Caracas concluded that the simple scheme devised would be worthwhile in socio-economic terms, whether or not a metro be constructed in the city. The scheme has not been implemented, but the metro is being constructed. The metro was recommended by a study realized before the road pricing investigation, and it could not, therefore, have been examined whether or not the metro would be worthwhile were the surface transportation system optimized, as it would tend to be were the road pricing regime introduced. This is illustrative of a trait observable in other Latin American cities as well as in Caracas (-Rio de Janeiro, São Paulo and Santiago, Chile, for instance-) to prefer expensive capital intensive "solutions" to urban transportation problems which seek to improve the conditions of travel of collective transportation users whilst not intruding on the "right" to use the private car, which seems to be treated as something akin to a Latin American sacred cow. It is generally not the case that metros are financed by the users of cars, the costs of the metro system being usually paid for by fares and from more general taxation revenue,

/which, in

which, in Latin America, may be to a large extent contributed by taxes on sales rather than the generally more progressive taxes on income. Note too, as is indicated in table 6.6, that in São Paulo at least, the metro is utilized by high income persons who probably also own cars.

There are certain signs, however, that certain cities of the Region are starting to consider the adoption of schemes which would physically transfer road space from the car user to the collective transportation passenger. Buenos Aires has several lengths of reserved bus lanes, one against the flow of traffic. But in other cases the prime mover behind such schemes does not seem to have been the desire to remove some of the incumbrances forced on the user of collective transportation, but rather something else. The improvement in the travel conditions of the transit user is almost a by-product. For instance, Santiago, Chile, has recently removed parking meters from city center streets in an attempt to reduce the amount of car usage to the center of town (less than two years after they were installed in the first place); but the prime reason for this seems to be to attempt to alleviate the amount of atmospheric pollution over the inner areas of the city 1/ and not to improve the fluidity of bus movement. In Rio de Janeiro a plan was announced in June 1979, to reserve two lanes on Avenida Nossa Senhora de Copacabana for buses. But one of the reasons for the adoption of this scheme, and maybe the principle one, is that there would result an expected saving in petroleum consumption.

There is without much doubt a real concern in Latin America that the travel conditions of the less affluent social classes must be improved. This is evident through speaking with those responsible for urban transportation by the bold actions taken in the construction of metropolitan railroads, by the actions taken by some public authorities in acquiring supplementary bus fleets, etc. But there seem to be little in the way of attempts to tackle the problem at the fundamental level though restraints on the excessive amount of car travel at inconvenient times, which largely created the problem of poor travel conditions for the less well-off in the first place. The

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1/ For which the private car may not even be significantly responsible - see table 7.5.



solutions attempted are not only possibly somewhat regressive in certain aspects; they are also inordinately expensive. The first line of the Rio de Janeiro metro cost more than US\$ 53 millions to construct per kilometer. Were the problems to be tackled at the basic level by reducing the quantity of car travel at peak periods not only would the "polluter" be called upon to cover the costs of his contamination, but the total costs of achieving the desired level of improvement would be lowered.

Table 6-1  
**TOTAL AND AUTOMOTIVE-RELATED FAMILY SPENDING IN 1975 IN  
 SELECTED PARTS OF BRAZIL**  
 (In cruzeiros)

Area (Indicating unit of the federation)	Total spending per family	Spending on:		
		vehicle mainte- nance	vehicle tax	car purchase
Rural MA, PI, CE, RN, PA PE, AL, SE, BA	7 543	21	4	88
Whole region idem.	13 229	66	29	338
Rural PR, SC, RS	19 028	145	51	596
Region idem.	29 038	255	116	1 128
Rural RJ	14 006	99	27	357
Region RJ	40 078	265	165	1 001

Source: "Anuario Estadístico do Brazil: 1977". I.B.G.E., Rio de Janeiro.

Table 6-2

THE DISTRIBUTION OF CAR OWNERSHIP BY FAMILY INCOME  
IN SAO PAULO IN 1977

Monthly in- come on Cr\$	Percentage of families with:					Percentage of all families
	0 Cars	1 Car	2 Cars	2+ Cars	No reply	
0- 700	96.6	2.5	0.5	-	0.4	1.22
701- 2000	91.7	7.7	0.5	0.0	0.0	10.25
2001- 4000	81.0	17.7	1.0	0.0	0.2	24.15
4001- 6000	62.2	34.4	2.8	0.3	0.4	18.34
6001- 8000	45.6	48.2	5.4	0.5	0.2	11.45
8001-12000	27.9	58.3	12.2	1.3	0.3	11.75
12001-16000	16.0	61.1	18.6	3.8	0.5	5.68
16001-20000	11.4	54.3	26.2	7.3	0.8	4.37
above 20000	5.8	42.6	38.0	13.4	0.1	6.78
All	54.6	34.5	8.3	2.1	0.5	93.99 <u>a/</u>

Source: Information provided by the Empresa Metropolitana dos Transportes Urbanos of the city of São Paulo.

a/ Excludes families which did not respond to the income question.

Table 6-3

TRIP-RATES PER DAY FOR FAMILIES IN BUENOS AIRES BY SOCIO-ECONOMIC STATUS <sup>a/</sup>, CAR OWNERSHIP, AND WHETHER OR NOT THE FAMILY RESIDES IN THE MORE BUILT-UP AREAS

Socio-economic status	Car-owning or not	Trip rate for families in:	
		Federal capital	Rest of Metropolitan area
High	yes	12.53	8.75
	no	8.07	5.12
Medium	yes	8.41	6.53
	no	5.71	4.75
Low	yes	6.53	5.36
	no	4.13	3.89

Source: "Estudio preliminar del transporte de la Región Metropolitana", Ministerio de Obras y Servicios Públicos. Buenos Aires, 1972.

<sup>a/</sup> Highly correlated with household income.

Table 6-4

DAILY TRIP RATES BY PURPOSE FOR FAMILIES IN SAO PAULO  
IN 1977 BY INCOME GROUP

Monthly income in Cr\$	Trips per day			Per family for purpose:					
	Work	Educ.	Shop	Pers. bus.	Health	Recreat. visit.	Serve pass.	Home	Total
0- 700	0.17	0.02	0.05	0.20	0.06	0.15	0.00	0.47	1.12
701- 2000	0.83	0.08	0.06	0.27	0.10	0.21	0.06	1.37	2.98
2001- 4000	1.47	0.19	0.08	0.35	0.14	0.27	0.10	2.14	4.73
4001- 6000	2.04	0.36	0.13	0.49	0.13	0.38	0.13	2.82	6.41
6001- 8000	2.20	0.51	0.12	0.59	0.14	0.42	0.17	3.22	7.36
8001-12000	2.42	0.75	0.16	0.62	0.14	0.56	0.24	3.70	8.58
12001-16000	2.54	1.01	0.24	0.79	0.13	0.66	0.42	4.14	9.94
16001-20000	2.35	0.98	0.26	0.85	0.15	0.74	0.58	4.41	10.02
above 20000	2.42	1.29	0.37	0.89	0.18	0.94	0.51	4.74	11.44
All	1.81	0.49	0.14	0.51	0.14	0.43	0.20	2.86	6.59

Source: Interpreted from information provided by the Empresa Metropolitana dos Transportes Urbanos of the city of São Paulo.

Table 6-5

MEAN TRIP DURATION AS A FUNCTION OF HOUSEHOLD INCOME.  
SAO PAULO, 1977

Monthly income in Cr\$	Minutes per trip
0 - 700	45.4
701 - 2000	53.5
2001 - 4000	51.8
4001 - 6000	46.4
6001 - 8000	42.2
8001 - 12000	37.5
12001 - 16000	31.4
16001 - 20000	28.1
above 20000	24.3

Source: Interpreted from information provided by the Empresa Metropolitana dos Transportes Urbanos of the city of Sao Paulo.

Table 6-6

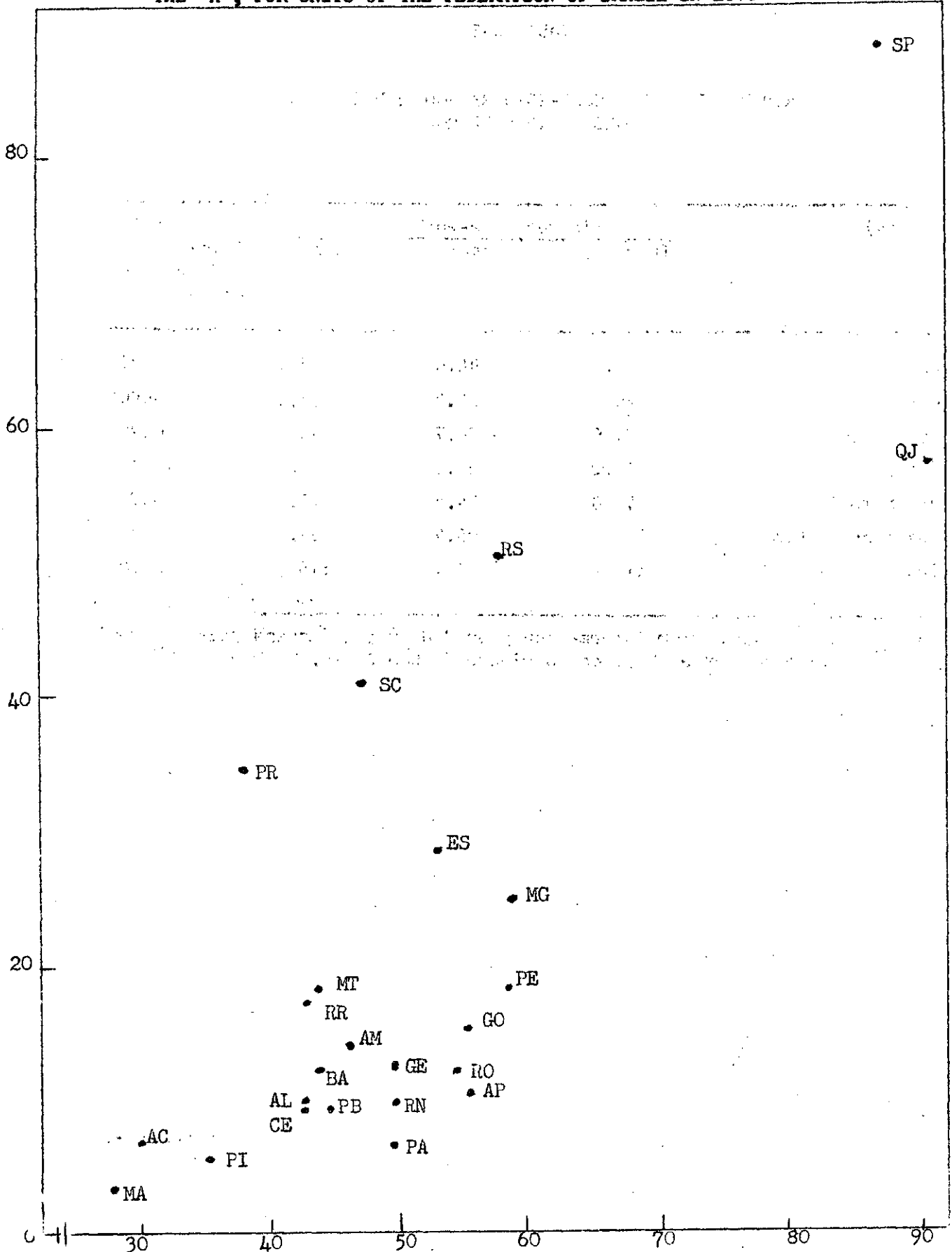
TRIP DURATION FOR HOME-TO-WORK JOURNEYS BY SELECTED  
COMBINATIONS OF MODES

Mode(s)	Minutes home-work			Mean family income in Cr\$ of users of mode(s)
	Industry	Commerce	Service	
Bus	46.9	48.0	47.2	7837
Car	24.3	26.0	27.6	14680
Bus + bus	77.9	76.7	79.9	6920
Métro	38.3	34.6	33.6	12920
Other train	73.0	74.4	72.0	5070
Bus + bus + bus	100.5	105.7	87.1	6400
Bus + bus + train	110.4	98.7	115.9	6810

Source: Interpreted from information provided by the Empresa Metropolitana dos Transportes Urbanos da cidade de São Paulo.

/Figure 6-1

Figure 6.1  
THE RELATIONSHIP BETWEEN RATES OF MOTORIZATION, IN VEHICLES PER THOUSAND PERSONS, SHOWN ON THE "Y" AXIS AND DEGREE OF URBANIZATION, IN TERMS OF THE PERCENTAGE OF THE POPULATION THAT LIVES IN URBAN AREAS, SHOWN ON THE "X", FOR UNITS OF THE FEDERATION OF BRAZIL IN 1975



Source: Anuario estadístico do Brasil, 1976



Figure 6.2  
QUANTITY OF INTERNAL (TO SAO PAULO CITY) TRIPS PER DAY PER FAMILY AS  
A FUNCTION OF FAMILY INCOME: IN TOTAL AND BY AUTOMOBILE

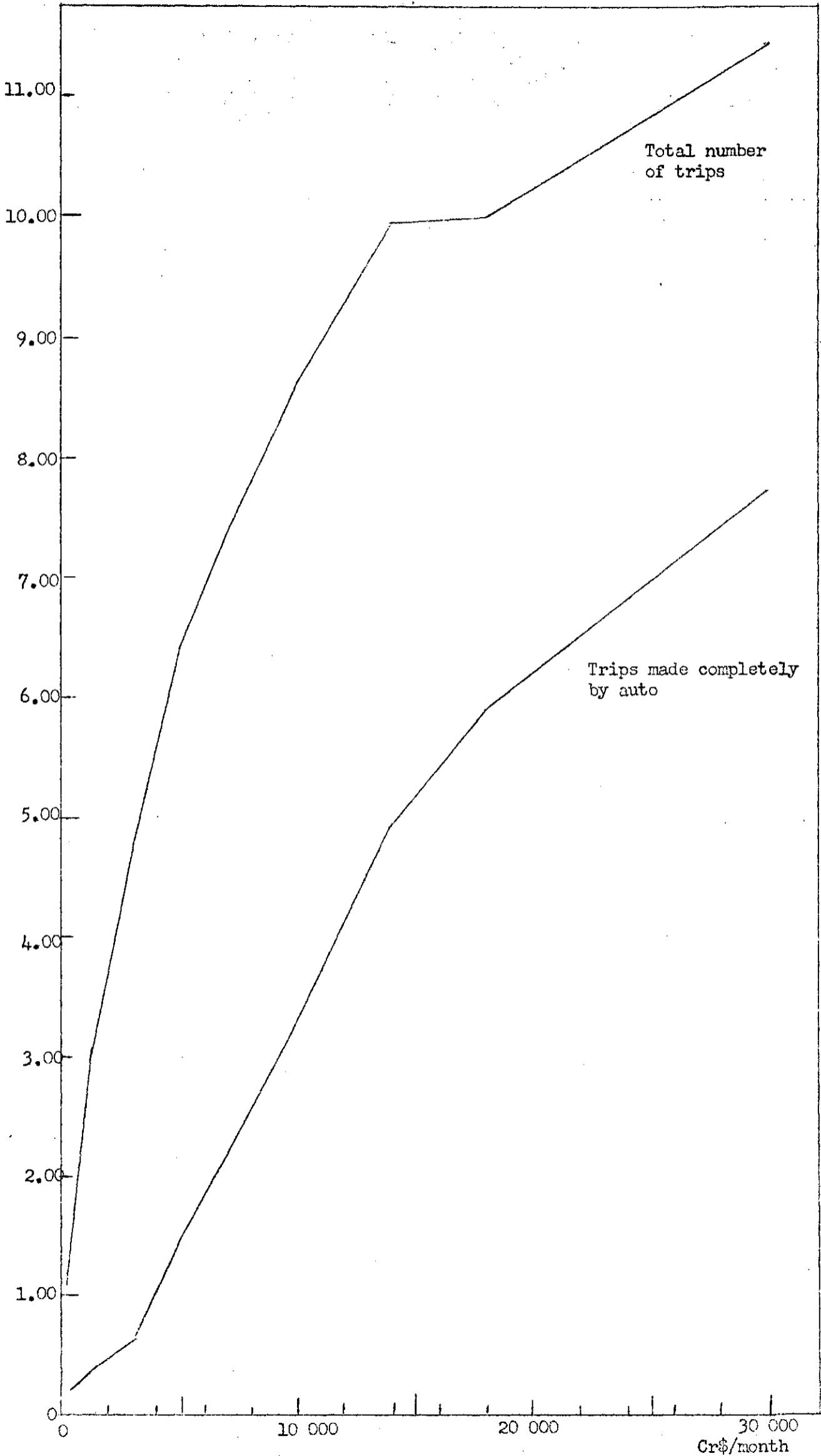
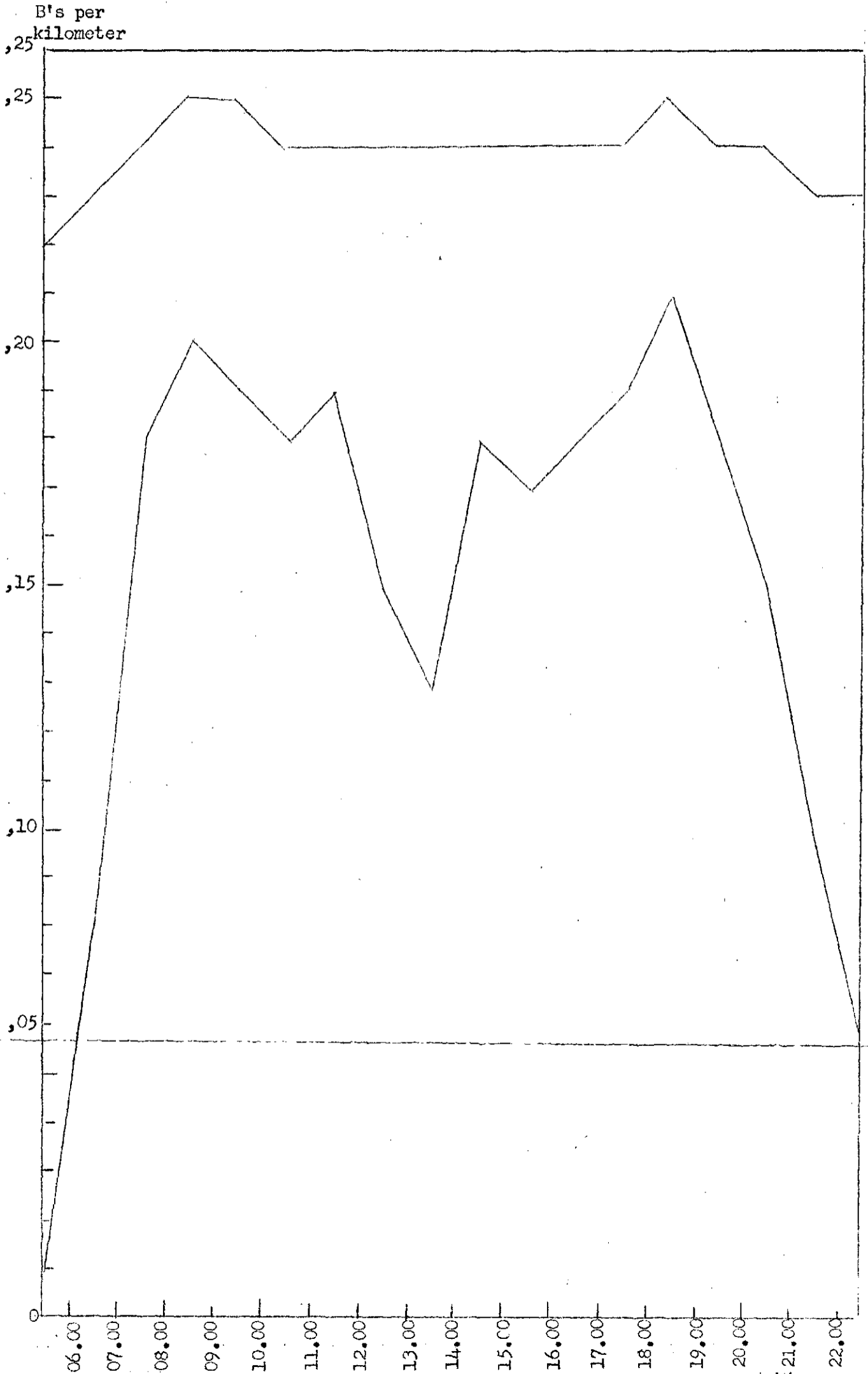


Figure 6.3

THE DIURNAL VARIATION IN, (a), DRIVER'S TIME AND OWN CAR OPERATING COSTS AND, (b), THE COSTS FORCED UPON OTHER ROAD USERS DUE TO THE PRESENCE OF AN ADDITIONAL CAR FOR A CIRCUIT IN INNER CARACAS, IN BOLIVARES OF 1971 PER Km. AND USING 1971 WEEKDAY MEASURES OF TRAFFIC FLOW AS BASE INPUT



## VII. SOME ENVIRONMENTAL IMPACTS OF THE AUTOMOBILE IN LATIN AMERICA: ACCIDENTS AND POLLUTION

### 1. Introduction

An automobile undoubtedly confers on its owner benefits derived from the greater accessibility which it permits. These benefits are probably large although hitherto non estimated. This current paper too makes no attempt at estimating the benefits derived from the accessibility generated by the automobile in any quantitative manner. (However in Annex 2 we present a methodological framework which could be adopted for their estimation.) Since we make no attempt to estimate the user benefits which the car unleashes it may be considered unfair to dwell too long on the matter of the various environmental and other social costs for which the car is responsible, since so to do may bias the reader's opinion towards a belief that the automobile in itself is an undesirable object. We are not trying to say that we believe that the automobile is undesirable for Latin America, although we do believe that it is allowed to be used in such a way that the owner and user does not consider the whole costs of his action to society when he decides to buy a car and use it. For instance, as explained in section VI, the car user does not pay for the costs he forces on the user of collective transportation when he makes a trip along a congested urban street which contains a bus route.

In the same way the car user generates both air and noise pollution, for which he may not cover the costs. He also starts each journey with a non-zero probability of killing or injuring somebody, maybe himself, before he arrives at his destination, of which probability he has little knowledge and which he can be argued to underestimate. In Latin America the non-appreciation of the dangers of car travel is seemingly very much greater than it is in the central countries if the evidence of the eye is anything to go by (failure to wear seat belts, lack of lane discipline, etc.). The non-recognition of such costs implies that some trips would be made and some cars would be bought when the benefits which follow on from such action be less than the costs involved. Thus there would be tendency for both too many cars and too much use of cars. Only were the potential car buyer and trip maker to be fully responsible for the costs of his action can

/there be

there be much hope that the right volume of car ownership and car usage be hit upon.

## 2. Accidents due to the car in Latin America

### (a) Accident rates in Latin America

There is no doubt that, from the standpoint of road safety, Latin America is a very dangerous part of the world in which to live. The bare statistics show this to some degree, although not always to the justified degree since one suspects that there is a positive correlation between the accident rate of a country and the rate at which those accidents which do occur fail to be reported, and hence recorded in the official statistical returns. Further evidence of the danger of being on Latin American roads is provided by regular hair-raising newspaper photographs and stories of the previous day's disasters on the highway, and by quite alarming and socially irresponsible behaviour seen whilst driving to work in the morning.

Table 7-1 shows some illustrative statistics of mortality rates in certain Latin American countries (for which data is readily available) in recent years, together with similar rates for some central countries for the years 1976 and 1955. We choose to concentrate on mortality rates rather than overall accident rates since it is suspected that differences in coverage and definition for overall accident rates between countries make inter-country comparison meaningless. There are difficulties too, of a like nature, in the case of death rates, but to a lesser degree; for instance some countries classify a death due to a road accident as being a mortality occurring within 30 days of a highway accident and causally linked to it (which definition is used by the United Nations Economic Commission for Europe) whereas other countries count only those deaths which actually take place at the place of the accident, whilst still others use intermediary definitions. The rates in the table are specified per motorized vehicle, although a better base for comparison would be the traffic volume in terms of vehicle-kilometers. The latter information is not available for most countries of interest.

/Taking as

Taking as an arbitrary base for comparison the simple average of the rates for the United States and the United Kingdom in the two years of 1955 and 1976, it would appear that Brazil in the 1974/1975 period was 6 1/2 times as dangerous, Chile between 1968 and 1973 was about ten times as dangerous, Colombia in 1969 was 15 times as dangerous, Ecuador in 1975 was 25 1/2 times as dangerous, Peru in 1972 was 4 1/2 times as dangerous, Venezuela in 1975 was 7 times as dangerous, whilst Uruguay in 1974 was comparatively safe at merely 1 1/2 times as dangerous as the base point chosen.

Data on accidents on highways for Latin American countries do not generally exist in a reliable and consistent form over a sufficient number of years to permit the determination of long-term trends. In the central countries, however, death rates on the roads per vehicle declined significantly from the mid-fifties to the mid-seventies: for instance the rate (in terms of deaths due to highway accidents per 1,000 vehicles per annum) in the United States fell from 0.61 to 0.34; in the United Kingdom it fell from 1.17 to 0.41; in the Netherlands it fell from 4.12 to 0.59; in France it fell from 1.92 to 0.74; in Italy it fell from 4.62 to 0.51. The available data would suggest that the rate in Chile fell from 1968 to 1971 to 1973, but there were other influences at work during this period; for instance in 1973 there were at times difficulties in buying gasoline. The Latin countries of Europe (Spain, Portugal, Italy and France) all lowered their death rates during the period however. The indications are that the rate was generally falling in Brazil from 1972 to 1976, although remaining at very high levels.

(b) Reasons for the high accident rates in Latin America

The reasons why accident rates are so high in Latin America have not been fully explained. There are many quite obvious contributory reasons, such as inexperienced drivers, cars of antiquated design, and inadequate sign-posting, but the true quantitative significance of each one has not been identified.<sup>1/</sup>

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<sup>1/</sup> There has been some seemingly pertinent statistical analyses to achieve such identification in São Paulo State. We have not had access to the complete results.

The British Transport and Road Research Laboratory however, has conducted some illuminating research into accidents in developing countries in general. It found that, looking at cross-sectional information from a variety of countries, the higher is the car ownership rate the lower is the accident rate per vehicle. But this relationship is certainly not in itself causal. The increase in the level of car ownership is generally accompanied by improvements in the level of education, perception of social responsibility, and quality of highway infrastructure, and it is such tendencies which lead to reductions in the accident rate and not higher car ownership in itself. It is probable that the accident rate in Ecuador, which country in 1975 had the highest death rate per vehicle of all entries in table 7-1, increased as car ownership increased in this country as a result of the oil boom of this country in the early and mid nineteen seventies. In the longer term however, such riches would be transformed into a raising of the level of education and highway infrastructure, etc., to eventually be reflected in a lowering of the accident rate per vehicle. The British institution compared information for a number of developed and developing countries for the years 1961 and 1971 and concluded that "the percentage changes in fatalities and injuries do not appear to be closely related to changes in vehicle ownership".

The same institution suggests that "the decrease in fatality rate per vehicle (through the passage of many years) could be due to the fact that vehicles with the highest rates are decreasing in numbers". It goes on to relate comparative accident rates with the ownership of bicycles and motor-cycles, which are recognized to be not amongst the safest of vehicles. Also pedestrian interaction is likely to be important; for instance the switching of shopping from the neighbourhood grocery store, butcher's shop, baker's shop, etc., to the supermarket reduces the degree of vehicle-pedestrian friction. The countries which received the most attention from the developing world in the British institution's analyses were in Africa and Asia; in Latin America the motor-cycle and the bicycle are less typical than in the countries of the two other regions. But a study of transportation in the metropolitan region of Buenos Aires examined data on vehicle usage

/and accident

and accident data to estimate accident propensities for different types of vehicle in this city. The index calculated for a car was 4, for a taxi 2, for a bus 19, and for a truck 14.

For Buenos Aires these indices are entirely plausible. Taxis are individually owned and operated by drivers who can be classed as professionals and who would stand to lose a lot of revenue were their vehicle to be off the road for any period of time due to having been involved in an accident. Buses too are in very much the same category with the important differences that their drivers feel that drivers of other vehicles fear them more than they fear other drivers (due to the greater size and weight of a bus compared with most other vehicles) and that a bus can take scrapes and other minor impacts without having to be withdrawn from service. In some Latin American cities, although this is not as evident in Buenos Aires as elsewhere, bus drivers stand to gain more revenue by driving in a sometimes quite reckless manner so as to maximize the time between their own vehicle and the vehicle in front of them on the same route. Truck drivers too sometimes take advantage of the fact that they drive vehicles which are generally bigger and weightier than most other vehicles on the road, and that they can carry on operating their vehicles even were they to have been involved in minor accidents.

As time passes and incomes increase one would expect that cars, especially, and taxis increase as a proportion of the total fleet and that the proportion of trucks and buses decline. Thus, the mere passage of time would tend to reduce the accident rate per vehicle.

The same British institution proved the statistical correlation between road width and the frequency of junctions and number of accidents in Jamaica. In another developing country away from the region the number of accidents was found to depend on horizontal curvature, junction frequency, surface irregularity, and vertical curvature. Thus one would also expect the accident rate per car to decline in a general way through time as the quality of the highway stock improves, through the provision of freeways with limited access, and the paving of rough gravel roads, etc.

The Brazilian Ministerio da Justiça has also conducted some research into accidents on highways. It was found that on the Via Dutra (between the cities of Rio de Janeiro and São Paulo) in the first three months of 1975 the accidents which did occur could be attributed to:

driver fault	39.6%
vehicle fault	14.4%
highway	27.6%
ambiental conditions	6.7%
others	11.8%

In urban areas, 70% of accidents were attributed to the fault of the driver. Speeds are also likely to be influential. The Brazilian Departamento Nacional de Estradas e Rodagem claims that the introduction of the policy to limiting speeds to 80 km/hr, to economize on the consumption of gasoline, coincided with a fall of 12% in the number of accidents and 19% in the number of deaths.

(c) The intrinsic safety of the Latin American car

One factor which does not show up in the evidence quoted above on the causes of accidents is the nature of the Latin American automobile, which is inherently more dangerous than cars elsewhere. Whether there be an accident due to the fault of the driver, the fault of the road, the weather, or a mechanical deficiency in the vehicle, there would be a higher chance that the accident have serious consequences in Latin America than in the central countries due to the inferior quality of the Latin American car.

One contributory factor to the unsafe nature of cars in the region is the usually very high cost of new cars. This provides an incentive to maintain in operation longer than desirable older automobiles constructed with bygone concepts of safety in mind, and also less safe due to physical deterioration, as a function of usage. In some countries vehicles have to be inspected for safety features in order to obtain a licence to circulate, but these are not always sufficient to ensure that vehicles conform with the desired standards.

/A further



A further contributory factor to the unsafe nature of Latin American cars is the fact that most of the cars produced in the region are built to designs long since out of production in their countries of origin and which would not meet current safety standards in such countries. For instance in Argentina in 1978 the following models were in production but not so in their original homelands: Citroën Ami 8; Dodge Coronado; Dodge Polara; Fiat 600; Fiat 125; early sixties Ford Falcon; Ford Fairlaine; old model Chevrolet Malibu; Renault 6 and Peugeot 404.

Latin American countries have generally been slow in adopting safety features in the cars produced within their boundaries. Consider, for example, the Volkswagen Beetle. When this vehicle ceased to be produced in Western Germany in 1977 it had many more safety features than its Brazilian equivalent. Amongst these features were three-point safety belts, seat head-rests and a body front portion which collapses on impact. Certain other features were installed in the Brazilian version only in 1976 when the Brazilian Government issued a decree enforcing the inclusion of certain safety equipment in cars produced nationally. On the other hand, the Brazilian Volkswagen Passat is virtually identical as regards safety features with the German model, since the entire design was imported from Germany, safety features and all, due to the desire of the Brazilian subsidiary to get the car onto the market with the minimum delay possible. In Brazil the car producers claim that they do not voluntarily install safety equipment in their vehicles since the buying public does not demand them. They are undoubtedly right in this respect. It requires that there be government action to protect drivers from themselves in Latin America, and, even more important, to protect them from others.

However, there are grounds for optimism regarding the safety features of Latin American cars. Some countries, such as Chile and Argentina, are tending to open up their home markets to imported vehicles, which would tend to conform to international safety standards, since it may be less profitable to modify the car for the sake of a few Latin American sales rather than sell the car with some equipment which the manufacturers would prefer to extract. (There however are some instances of foreign manufacturers taking advantage of the lack of enforcing regulations in Latin America regarding the quality of the

/cars sold;

cars sold; in the pollution field, for instance, small imported cars with two-stroke motors are sold in Chile without the filters which are required in Japan.) Cars produced in Latin America are steadily being more and more sold on the international market, especially those from Brazil (which have been exported to many countries, such as Western Germany, Algeria, Philippines). Thus the product has to conform to the safety standards of the export market, and in most cases one would expect that the manufacturers choose to avoid unnecessary duplication of effort and produce the same version for the home market as for the export market. Furthermore government action in the area of requiring that new cars produced and/or sold have certain minimum safety standards will probably increase, to some extent, maybe, since by upgrading the cars produced to international safety standards new export horizons could be opened up.

(d) The relative importance and cost of highway accidents as a source of death: conclusions

Deaths from highway accidents figure quite highly in figures of death from all causes in Latin America. In developing countries in general road accidents cause more deaths than either typhoid or tuberculosis or smallpox or malaria. Table 7-2 shows some data of deaths from road accidents and other causes in certain Latin American countries.

The estimation of the cost to the nation of road accidents is a subject fraught with difficulty. A crucial problem is how to value human life. To a non-Christian the value of his life may be infinite. Since every year in every country non-Christians die in highway accidents then the costs of such accidents every year may be infinite.

There are several alternative procedures to value human life (or the loss of human life). These are:

(i) One may estimate how much persons are willing to pay to reduce the probability that they die. There are a number of difficulties here. A person generally does not know the danger to himself of crossing a busy road, flying by a certain airline, smoking so many cigarettes of a certain manufacturer per day, etc. Furthermore he cannot reasonably be expected to pay on account of the pain and grief that his own death would cause others. Finally, it is sobering to take note of the concluding remarks of one

/researcher who

researcher who has attempted to value life by studying how much people are prepared to pay to stand a better chance of not dying are "Precisely how the translation from private preferences to social welfare functions should be performed we hesitate to suggest".

(ii) The latter problem, and maybe the one of the loss felt by friends and relatives, would be avoided were one able to determine how much governments are prepared to spend to save the lives of the people for which they are responsible. But even governments may not know what the relevant probabilities are. The behaviour of one ministry may not be consistent with another. And there may be some circular reasoning involved; for instance, the benefits from highway improvements utilize an assumed value of life (saved by reducing accident rates by providing better roads). So were one to study the behaviour of governments as to how much they spend to save lives by installing safety equipment on highways, and were one not to err in one's calculations, one should derive that the value of life by the value which was assumed in the first place.

(iii) One could feasibly take as the value of life the discounted net future earnings of the deceased on the grounds that society would be that much the worse off through the victim not being alive. Clearly there are a large number of problems with this approach. It places no value on the extent that the deceased would prefer to be alive rather than dead. Also the same procedure would usually conclude that most women, many elderly men, most of those living in the developing world, and young children everywhere would benefit the rest of us were they to cease to exist, a conclusion which is clearly ridiculous. Nevertheless this approach has found considerable acceptance amongst the somewhat cold-hearted engineers and economists who provide cost data for transportation studies. Were the approach to be combined with (i) it could, however, yield acceptable results.

(iv) One could gain an insight into the costs borne by the friends and relatives of the deceased by studying awards in court cases claiming compensation for losses inflicted. This possibility too could be used in association with (i). One may also utilize the awards laid down in conventions, such as that of Warsaw, which specify how much the bereaved

/should be

should be compensated for the loss of their loved ones in transport accidents. A practical problem with this approach is the inconsistency of the results obtained depending on the convention chosen.

Nevertheless, a study of transportation in the metropolitan area of Buenos Aires used method (iii) above to determine that the every death in a road accident in Buenos Aires corresponded to a cost due to all accidents on the roads of this city of approximately 1.3 million pesos of 1973. This figure does include some allowance for the losses felt by the bereaved, but for the most part is based on the value of lost production and costs of repairing men and machines. Using the value estimated for Buenos Aires, and making suitable adjustments for inflation, one may use the result to (very crudely) estimate the cost of road accidents as a proportion of the GDP of Latin American countries. The estimates made are subject to many errors, and their true significance is not wholly obvious, nevertheless they vary, for the Latin American countries dealt with in table 7-1 from a low percentage of 0.8% for Peru in 1972 and the República Oriental del Uruguay in 1974 to as much as 4.8% for Ecuador in 1975. The British Transport and Road Research Laboratory has estimated that the costs of road accidents to developing countries in, mainly, Africa and other countries with relatively low levels of motorization, to be around 1% of Gross National Product. In Latin America one would expect that the percentage be somewhat higher than in developing countries on average, due to more vehicles and more accidents. The Brazilian Ministerio da Justiça in the report referred to earlier provides information of material damage costs and "vitimas com ferimentos" (which may or may not include the lost production through the person getting himself injured) from which it can be deduced that in 1972 and 1973 the cost of highway accidents, so defined, was somewhat less than 1% of Brazilian Gross National Product.

Nevertheless, perhaps the whole idea of estimating the costs to a nation of the death and other damage caused by road accidents is futile. Some nations, such as the United States, United Kingdom and Sweden, spend vast sums in attempts to reduce the number of highway accidents (while not discouraging car usage). At the limit a country could spend most of its Gross National Product on minimizing road accidents, in which case the costs

/of the

of the accidents themselves would clearly not be a fair indication of the amount of the wealth of the nation diverted from consumption because of road accidents.

It is without doubt however that road accidents are both a significant cause of death in Latin America and that they cost the nations of the region too much. There should be more legislation introduced to minimize such costs. Much of the current legislation is antiquated and inadequately enforced. In Argentina the laws which govern vehicle use date from the late nineteen forties. They do not, for instance, require cars to have reversing lights. Although revised since their initial specification, fines seem to have been overtaken by inflation. Some of their dispositions, such as the 40 km/hr urban speed limit, are not heeded.

In Chile it has been found that knowledge of the code of transit is very poor. In some cases there is even passive encouragement by the responsible enforcing authorities to break the basic rules of the road, such as giving way to traffic on roundabouts. In Santiago, Chile, the cause of road safety is not helped by the installation of a large number of traffic lights which seem to exceed the ability of the responsible authorities to maintain them. Their proliferation and mal-functioning seems to be a reason why they are not well-respected.

In Brazil, one may be forgiven for thinking that only buses obey the 80 km/hr general speed limit whilst cars may not heed to it.

There is clearly considerable hope that road safety in Latin America improve in the future, even if only because there is so much room for improvement from the present unsavory situation. The improvement needs to be on all fronts, by minimum safety standards for cars, by updating transit laws and raising fines and levels of enforcement, but maybe especially by driver education.

### 3. The automobile and air pollution in Latin America

#### (a) Principal automotive-related air pollutants

In chapter VI it was made clear that automobile ownership, and to a lesser extent, usage was concentrated in the urban areas of the region. This has social implications as pointed out in that chapter. It also has implications from the standpoint of air pollution, in much the same way as the social implications already indicated; the automobile forces costs on society in general, and the captive users of collective transportation more than most, through lowering traffic speeds, and, in the same way, it generates air pollution which affects all and the costs of which are not reimbursed by those who create the nuisance. It regresses the income distribution.

There are several forms of air contaminant produced by the automobile in significant quantities. These are introduced below.

Carbon monoxide. This gas is liberally emitted by gasoline-powered motor vehicles, all other sources being insignificant. CO combines chemically with the hemoglobin in the blood thereby decreasing the capacity of the bloodstream to carry oxygen to the parts of the body which depend on it. The effects have not been fully researched to a degree that permits the relevant authorities to agree on the level of danger; some authorities feel that the effects of CO become significant when there has been exposure at a concentration of 30 parts per million (ppm) for four hours. The contaminant may lead to some loss of mental ability and may consequently be a cause of traffic accidents in city streets. However one respected medical authority has put the true significance of CO in some perspective by claiming that with each puff of a cigarette a smoker inhales seven times as much carbon monoxide as the highest concentration found in heavy traffic.

Hydrocarbons. By chemical reaction HC may contribute to the formation of smog, which is a serious concern in some cities. There is no direct evidence that the kind of concentration of HC found in city streets is harmful, although there have been suggestions that it be connected in some way with lung cancer. Gasoline motors are much more contaminating than diesel motors, and the major source of the total hydrocarbon pollution is the motor vehicle, as pointed out in table 7-3.

/Nitrogen Oxides.

Nitrogen Oxides. The real long-term effects of  $\text{NO}_x$  are largely unknown at the present. The gas contributes to smog formation and can lead to respiratory failure in high concentrations not found at the streetside. Some authorities consider that the effects of  $\text{NO}_x$  may be more harmful than those of  $\text{CO}$ . Again vehicular transportation is the major source of nitrogen oxide contamination and the petrol engine is generally more polluting than the diesel motor.

Lead. Lead pollution may take the form of either particulate matter or volatile compounds. There is no evidence that lead pollution usually produced by automotive sources is a health hazard, although there is no doubt that harmful effects follow from the ingestion of much higher concentrations. The element accumulates in the body and can seriously impair mental ability, especially when ingested by children. Lead is added to gasoline to improve efficiency and reduce knock.

Table 7-3 shows quite clearly that the gasoline motor is generally more polluting than the diesel motor, and that motors are generally more polluting in those modes found in urban traffic, i.e., idling, accelerating and decelerating. It should be borne in mind too that older cars without special pollution control devices may produce more than 50% more  $\text{CO}$  than new cars which are well-tuned. There are many cars on the roads of Latin America which are both old and badly tuned. Furthermore in some of the smaller countries of Latin America which rely on car imports from outside the region the pollution problem is made very much worse through the expansion of the fleet of small imported cars with two-stroke motors. These cars have engines which are lubricated via the combination of oil with gasoline. The burning of such oil causes considerable pollution, somewhat alleviated were the cars fitted with a special filter. In Chile, at least, cars with two-stroke motors are imported without filters. Many motor-cycles too have two-stroke motors and, in same way, are significant contaminators.

On the other hand the diesel motor is relatively innocent, although this fact is not well appreciated by public opinion in Latin America. In some cities diesel buses and trucks are hailed as being contaminators of the air whilst cars with less visible exhausts are quite exonerated. The fact that diesel fumes are visible hides the fact that such fumes contain fewer gases of types

/which are

which are thought to be potentially dangerous to human health. In the United States those gasoline powered cars with Government-stipulated catalytic convertors are still worse than diesel motors from the standpoint of HC and CO emissions, and all diesel engine cars in the United States meet current regulations from the standpoint of the other pollutant which is the subject of federal control in the United States, NO<sub>x</sub>. In the United States investigations are proceeding apace to try and detect any association between the particulate matter emitted by the diesel motor and forms of cancer, but to date they have failed to prove any significant relationship. A diesel car emits around 50 times as much particulate matter as a gasoline car, but it should be borne in mind that the major originators of particulate matter in the air are usually fixed sources such as coal and oil-powered power stations.

The available evidence does suggest that from the standpoint of human health, the diesel motor is quite innocent. Thus the concern in Latin America for the fumes produced by buses and trucks is consequently equally ill-founded on this ground, although there are undeniable costs associated with the diesel on account of laundry bills and dirty building facades. There are very few diesel cars in Latin America; in Buenos Aires there are some diesel-powered taxis, which are also found elsewhere; in Brazil diesel car production is prohibited by law so as to reserve the consumption of the subsidized diesel fuel for trucks and buses (and a few German Mercedes-Benz diesel cars imported by diplomats of high rank, which cars use fuel subsidized for the social reasons mentioned). On the other hand, there are quite a few petrol powered trucks and buses in Latin America so that the pollution derived from vehicular sources is not a matter which is confined to the automobile.

(b) The contribution of the automobile to total pollution in Latin America

There is little information on the contribution of the motor vehicle to total pollution levels in Latin American cities, although information is now being generated on a much greater scale than previously, especially in those cities, such as São Paulo and Santiago, Chile, which admit to having a pollution problem, and also some others, such as Buenos Aires where the problem is less obvious but still thought to be worthy of being monitored.



Table 7-4 shows the total contribution from transportation sources of certain important pollutants in two cities of the region and two cities elsewhere. It shows that transportation, and largely road transportation and predominantly the car, is the main producer of HC, NO<sub>x</sub> and CO. Some of the differences between the cities portrayed are probably not real, being rather due to differences of measurement principle. Others are real. For instance in Buenos Aires power stations produce large quantities of NO<sub>x</sub>, which is avoided by Santiago through greater reliance on hydroelectric energy. Also in Buenos Aires the burning of garbage is a much greater generator of CO pollution than in Santiago.

Table 7-5 refers to Santiago, Chile, and illustrates a fundamental difference between this city and those in the central countries in that the private car is a minor source of contamination compared with taxis and buses. The reasons for this are that many buses are gasoline powered in the city, that car ownership relative to the size of the taxi fleet is small, and that buses and taxis may have worse maintained motors than private cars. Santiago is no doubt an extreme case since it relies to a greater extent on diesel buses than most other cities of the region; in Brazil, for instance, there are virtually no petrol driven buses at all. Furthermore, in Santiago the mean age of the taxi fleet is apparently great, even by the standards of Latin America, and its components are often badly maintained by their owner-drivers. But nevertheless, on a lesser scale, one would expect that in Latin America the responsibility of the private car for atmospheric pollution be less than in the central countries. Thus, the implications of automotive-sourced air contamination in the region would be made less severe than otherwise would be the case since, to a large degree, those who benefit from the accessibility afforded by those vehicles which create pollution are the same persons as those who are malaffected by the contamination generated. Were the major part of such contamination produced by the users of private automobiles this would be regressive in terms of the distribution of welfare since such privileged persons would inflict any evils which follow from air pollution on the population in general, including the less affluent who do not benefit from the increased accessibility which the pollution makes possible.

/Overall city-wide

Overall city-wide information on pollution, however, may not be a very good guide as to the maleficial consequences of such pollution, even when, as in table 7.4, the information is presented by type of pollution. In cities with reasonably good air circulation, such as Buenos Aires and Montevideo, any given amount of pollution would have less consequence than in a city, such as Santiago, Chile, where there is inferior circulation. Even less meaningful is information, widely quoted, on the total weight of pollution generated by a city. It is extremely unlikely that one ton of CO have the same disadvantageous qualities as one ton of NO<sub>2</sub>, in the same way that one gallon of beer has a different degree of harm from one gallon of gin, even though the consumption of either may have undesirable effects.

(c) Specific concentration of pollutants associated with the automobile

A better guide as to the possible harm imparted by automotive-generated pollution may be given by concentrations measured at the streetside, of which some samples have been taken in cities of the region. In São Paulo CETESB has monitored CO and NO<sub>2</sub> levels at two city-centre stations since 1976. There is clear evidence that levels are falling from their once very high concentrations, thereby indicating some success for the environmental protection being carried out in that city ... 8 hour maximum levels for CO were 30 ppm in mid-1976 declining to almost half this concentration by the end of the following year. In California a concentration of 30 ppm during an 8-hour period is classed as serious by the state air quality standards whilst the same term is used in New York for an intensity of one-half the serious level of California. In São Paulo city centre concentrations of NO<sub>2</sub> have fallen from a high of 93 ug/m<sup>3</sup> on average for one month in 1976 to generally 10% less than this during 1977, with there being higher concentrations in the winter months. The United States Environmental Protection Agency classifies an annual mean of 190 ug/m<sup>3</sup> as being needed to protect humans. NO<sub>2</sub> does not figure amongst those pollutants monitored in São Paulo for the purposes of the emergency action plan. (See below.)

In Buenos Aires some very high streetside concentrations of CO have been recorded during the evening peak period, up to 77 ppm, although typical levels vary from 5 to 25 ppm. The accepted "serious" 1-hour concentration in

/California is

California is 120 ppm whilst, once again, the standard for New York is one half that for California. The Buenos Aires readings are not significantly different from those in other cities in the central countries.

Higher levels still have been measured in Santiago, Chile, where the daily average of CO level in the centre of the city has attained 64 ppm. The 8-hour serious level in California is 30 ppm, whilst New York uses a standard of one half that of California, whereas the Environmental Protection Agency (EPA) of the United States sets at 9 ppm the 8-hour concentration needed for the protection of human health.

In central Santiago annual average  $\text{NO}_2$  levels have reached 61 ppm, whilst momentary peaks of 440 ppm have been measured.

The most abysmal air quality in all of Latin America,<sup>1/</sup> however, probably occurs in the road tunnels of the city of Rio de Janeiro. In the tunnel Reboucas of this city the intensity of lead has been measured as reaching 37  $\mu\text{g}/\text{m}^3$  on average; in the period before the rush hours the ventilators in this tunnel are disconnected with a consequence that the concentration of lead rises to 70  $\mu\text{g}/\text{m}^3$ . There are comparatively few standards laid down for lead pollution, but the level in Rio compares with a typical intensity of 10  $\mu\text{g}/\text{m}^3$  on a busy highway and 15  $\mu\text{g}/\text{m}^3$  in a road tunnel of Rio de Janeiro but they are probably extremely high. To remain in any such tunnel during a spell when the traffic flow be stopped for any reason would almost certainly be harmful from the health standpoint.

One cannot conclude too much, due to lack of information, about the levels of contaminants in the air at the streetside in the cities of Latin America except they are often above the accepted international standards in many cases. Even though agreed safe levels for most pollutants have not been set the levels of the cities in Latin America are high enough to warrant public concern and action by the authorities. Unfortunately the past history does not indicate that the response to air pollution from automotive sources by the

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<sup>1/</sup> Except maybe in busy underground parking lots, from which no measurements are known to have been made available.

authorities concerned in Latin America has been up to the standards of most of the central countries. There has been legislation decreed to control contamination of the air but results are sometimes disappointing.

(d) Some attempts to control automotive sourced pollution in Latin America

At least two cities in the region have adopted plans similar to that of Los Angeles in the United States, whereby the levels of specific pollutants are monitored so that when critical concentrations are attained avoiding action may be taken. The pollution control legislation which governs the city of Buenos Aires was enacted in law 20.284 of the Republic as published in the "Boletín Oficial" of 3 May 1973. Amongst the features of the law is the laying down of three worsening levels of concentration for six contaminants. The attainment of the specified levels may bring forth surveillance or actions, as deemed appropriate, to bring the level of contamination back down to acceptable levels. The "alert" level of contamination is declared when pollution has attained certain specific concentrations (see table 7-6) that, bearing in mind the prevailing atmospheric conditions, make it possible that the "alarm" level be reached. The highest level specified in the law is the "emergency" level which is declared when "alarm" intensities have already been attained and the attainment of emergency levels is possible. The law authorized the "prohibition and limitation of operations and activities in the affected zone" so that concentrations be reduced. The intensities laid down in the law are detailed as table 7.6. They are not significantly different from the levels laid down in the United States and elsewhere for concentrations of pollutants which give rise for concern.

The same Argentinian law also makes other stipulations. Amongst these is the requirement that all vehicles entering the fleet be submitted to tests of their emission levels for CO and HC within three years of the passing of the law. Such vehicles should have licences granted by the national health authority before they be allowed to circulate. The text of the law refers to norms fixed by it, and which have to be met, but the law itself makes no mention of what these norms are, it presumably being up to the health authority to set its preferred levels. On this matter the law seems to leave an undesirable air of ambiguity. Another failing of the law is that the emissions

/limits are

limits are laid down were the vehicle to be maintained as recommended by the manufacturer. The owner of the vehicle is not required to maintain his acquisition as specified by the manufacturer, and hence there is no guarantee that a non-polluting vehicle stay non-polluting once it has left the factory gate.

The State of São Paulo, by means of law N° 997 of 31 May 1976, has a similar plan to Buenos Aires, also specifying three levels of concern for various pollutants. It differs with respect to the kinds of pollutants included within its embrace and the concentrations permitted at each level. The descriptors of the levels too are different from those in Buenos Aires, for instance the "Alert" level of São Paulo corresponds to the "Alarm" level of Buenos Aires. Since the introduction of the law the alert level has never been reached, partially due to the effectiveness of other provisions of the law. For example, all stationary polluting sources are required to be licensed. In São Paulo levels of automotive-related contamination have also been reduced through other measures, such as the pedestrianization of streets in the city centre and the spread of the trolleybus and the metropolitan railway.

The approach adopted in Chile has been different. Chile is still in the process of determining the most appropriate legislative action to take on the atmospheric pollution front, but there have been a string of measures over the year to mid-1979, designed to combat pollution in Grand Santiago especially. From calendar year 1979 vehicles are required to have passed a carbon monoxide pollution emission test (in the case of gasoline powered vehicles) in order to get a license to circulate. There seem to have been problems in enforcing effectively this requirement. Many of the garages authorized to measure carbon monoxide concentrations did not acquire the necessary measuring equipment and, according to reports, resorted to measurement of this invisible gas by observing the color of the exhaust emitted. No vehicle in Santiago, whatever the quality of its exhaust gases, seems to have had trouble in obtaining the necessary certificate exonerating it from emitting significant amounts of CO gases.

/Nevertheless Santiago

Nevertheless, Santiago is continuing with its attempts at controlling emissions at the level of the individual car, probably the most direct way to tackle the problem, although the prior experience of the city does not inspire too much confidence that the method be feasible in Latin American conditions. From the first of June, 1979, heavy fines were to be applied to the owners of gasoline powered vehicles which exceed the following concentrations of CO in their exhaust gases: 3 1/2% for vehicles of manufacture in 1978 and 1979; 4 1/2% for vehicles produced since 1972; and 6% for older vehicles.

Other measures taken in Santiago, Chile, with the specific objective of controlling pollution include the removal of parking meters from some downtown streets (less than two years after they were installed), and the withdrawal from service, much delayed due to the impact on the quality of the collective transportation of the city, of some 300 Chevrolet microbuses. Public concern about pollution in Santiago is higher than in other Latin American capitals, and indeed the problem is compounded by the unfortunate situation of the city which is conducive to smog. There is still some confusion about the desirable policy but it seems that the city is in the process of switching from a programme of encouraging the use of cars to the city centre, as evidenced by the provision of public parking blocks in the centre and the installation of parking meters, to a more restrictive stance. There are also discussions about further means, such as the levying of tolls or licences from those who pollute, and the prohibition of the importation of vehicles which do not conform with the emission regulations of their homeland.

Buenos Aires has also recently issued a decree that would require emission tests on vehicles registered in the city, as published in the "Boletín Municipal" of 14 December 1979. Prototypes of each new model produced in or imported into the country must be submitted for inspection for emissions of CO and HC in order to be granted permission to circulate. Checks also may be subsequently required on examples taken from the production line or from imported batches, with slightly greater tolerance levels. The permitted emission levels are generally those laid down by the United Nations Economic Commission for Europe. One doubts whether this law will be very successful in reducing pollution levels. It does nothing to require that vehicles be

/maintained in

maintained in a non-polluting state; it is generally appreciated that the imperfect regulation of motors can markedly increase emissions. However, in view of the difficulties which Chile is experiencing in controlling emissions on vehicles already in circulation, maybe the Buenos Aires law is reflective of what can reasonably be achieved.

There is no Latin American nation which has taken firm steps to control the concentration of lead in gasoline. Table 7-7 shows lead concentrations in the gasoline in various countries.

Table 7-7

LEAD CONCENTRATION IN THE GASOLINE OF VARIOUS NATIONS,  
IN 1979 a/

Country	Grams of lead per liter of gasoline
Brazil	0.845
Austria	0.40
Canada	0.549
Western Germany	0.15
France	0.45
England	0.45
Greece	0.84
Israel	0.42
Japan	0.26
Sweden	0.15
Switzerland	0.54
United States	0.34
Western Germany (1972)	0.613
Canada (1972)	0.655
United States (1972)	0.557 - 0.779
Mexico (1972)	0.75 - 1.08

Source: "Journal do Brasil" of 23 May 1979, taken from research findings at the Federal University of Rio de Janeiro; and "Las gasolinas en México" by Francisco Ramirez (paper presented at the first meeting on the problems of environmental contamination, Mexico, January 1973).

a/ Except where stated.

/The central

The central countries have generally taken steps to reduce the concentration of lead in gasoline in recent years, but this has not generally happened in Latin America, due to its adverse effect on combustion efficiency.

It may be concluded, in general terms, that the experience of the region, from the incomplete knowledge available to us, regarding the control of automotive emissions through legislation and other action by the relevant authorities has not been very successful. Some laws seem to be badly drawn up, while others have been beyond the capacity of the authorities to enforce them. That they have been decreed at all though is plain evidence that the countries of the region are concerned about the concentrations of pollutants in the atmosphere. There seems to be some lack of basic research into what is the best type of action to adopt, whether there should be broad limits set with plans of action developed to restrain emissions when critical levels be attained, whether it be sufficient to inspect just new vehicles, or whether there should be regular checks on vehicles already in circulation. There are also conflicts of interest from which the cause of air pollution reduction may come of second best. For instance in Chile, it is desired that small cars should be imported at only a 10% of import duty so that the lower middle class may have better access to cars; many of such cheap cars with two-stroke motors, are inherently polluting. The reduction of lead concentration in gasoline tends to increase specific fuel consumption. The opportunity to acquire relatively innocent diesel cars in Brazil is forbidden to all but the higher diplomatic ranks since they would make use of fuel subsidized for the benefit of truckers and bus companies. To take out of circulation buses which cause severe pollution may cause the reduction of the quality of collective transportation to below already very low levels.

Latin American countries have in the main tended to follow the measures adopted in the central countries, for instance on permitted levels of pollutants. There is no guarantee that they be appropriate in local conditions. This underlines the need to consider the problem, if indeed it is a problem, on a more consistent and global approach than has often been adopted to date.



Table 7-6

AIR POLLUTION NORMS AND DANGER CONCENTRATIONS AS LAID DOWN IN  
LAW 20.284 OF THE ARGENTINE REPUBLIC

Contaminant (Unit)	Norm	Alert level	Alarm level	Emergency level
CO (ppm)	10 - 8 hr	15	30	50
	50 - 1 hr	100	120	150
NO <sub>x</sub> (ppm)	0.45 - 1 hr	0.6	1.2	
		0.15 - 24 hr	0.3	0.4
SO (ppm)	0.03 (monthly mean)	1 - 1 hr	5	10
		0.3 - 8 hr		
Oxidants in gen. (ppm)	0.10 - 1 hr	0.15 - 1 hr	0.25	0.40
Par. in suspension (ug/m3)	150 (monthly mean)	Not applicable		
Part. sediment. (ug/m3)	1.0 (30 days)	idem.		

Source: Boletín Oficial de Buenos Aires, edición del 3 de mayo de 1973.

Noise pollution from the automobile in Latin America

The evidence would suggest that noise pollution is of much lesser concern to Latin Americans than to North Americans and Europeans. The matter has received comparatively little attention in the region and evidence abounds that the Latin American tolerance for high levels of noise is ample. The noise from traffic and other sources which so disturbs foreigners in Rio de Janeiro is not commented upon by Cariocas; non-chileans praise the curfew in the night hours of Santiago due to the quietness it affords airports are placed well within city limits, on occasion, such as Galeão in Rio de Janeiro and Aeroparque in Buenos Aires, to an extent which would not be tolerated in most central countries.

In contrast the situation with regard to air pollution, noise pollution tends to involve diesel vehicles more than those powered by gasoline, and thus remains outside the main concern of this paper. Other responsible vehicles are motor-cycles and petrol cars which are either badly-maintained or tampered with by their owners with the object of being a noise nuisance - mainly rods and sports models. Table 7-8 indicates the relative noise nuisance of the components of the traffic stream in a location in England. One would expect that the component of the total noise nuisance due to the car be slightly higher in Latin America, but this would scarcely raise the car to being a significant noise source.

Some noise measurements have been made on streetsides in Buenos Aires in 1973 and 1978. It was found that overall noise levels fell over the period covered, but the peaks in 1978 were sometimes the higher. The arithmetic mean of readings on a selection of downtown streets in 1978 was 70.47 dB(A)<sup>1/</sup>, not significantly different from what one would have expected in the central countries. The investigations in 1978 concluded that the noise level was adversely affected by: (i) defficient silencers, (ii) inadequately maintained bodywork, (iii) the unnecessary use of car horns.

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<sup>1/</sup> As measured 1.20 meters from ground level near intersections.

There seem to have been few serious attempts at limiting automotive-sourced noise in the region except with regard to the sounding of car horns. In Río de Janeiro even the prohibition of the sounding of car horns, except in emergencies, was only enacted in 1975 and then only on a selection of residential streets in highly trafficked areas hemmed in by tall buildings.

In Buenos Aires maximum noise levels are laid down for each type of vehicle by Ordenance AD 560.10 of the city of Buenos Aires as shown in table 7-9. This ordenance lays down as well strict procedures to be followed for the measuring of noise levels from specific vehicles. These are no doubt necessary since noise readings depend critically on factors such as the distance of the microphone from the source, and the background noise level, but they make it virtually impossible that an offender be apprehended, unless the policing authorities be virtually 100% sure that he be guilty since otherwise there would be a public outcry due to the hauling away of vehicles to a special site for noise reading purposes. One notes that in the United Kingdom in 1970 there were only two successful prosecutions of motorists for exceeding permitted noise levels, and these jointly generated a revenue from fines of US\$ 5.

Were the countries of the region to decide that automotive-sourced noise pollution should be controlled this should may be proceed via:

(i) The inspection of vehicles when applying for licence renewal for faulty silencers, etc.

(ii) The insulation of noise generators in new vehicles.

(iii) The concentration of traffic on as few a number of thoroughfares as practical, since and  $x\%$  increase in volume on a street increases the noise nuisance by much less than  $x\%$ .

(iv) Assistance to those who have noise contamination forced upon them (but not those who have volunteered to buy dwellings or rent offices known to be close to noisy streets) so that they may install double-glazed windows and other insulating devices, ideally financed by a tax on the users of the offending vehicles.

Table 7-1

DEATHS DUE TO HIGHWAY ACCIDENTS IN VARIOUS COUNTRIES  
IN VARIOUS YEARS PER MOTORIZED ROAD VEHICLES

Country	Year	Number of deaths	Death rate per 10 <sup>3</sup> vehicles
Brazil	1975	15 471	2.49
Brazil	1974	14 012	3.07
Chile	1973	1 658	4.29
Chile	1971	1 871	5.42
Chile	1968	1 448	5.69
Colombia	1969	1 935	6.50
Ecuador	1975	1 405	11.24
Paraguay	1976	138	
Peru	1972	727	2.06
Uruguay	1974	170	0.72
Venezuela	1975	4 001	3.02
United States	1976	45 482	0.34
United States	1955	38 426	0.61
Canada	1975	6 061	0.55
Great Britain	1976	6 570	0.41
Great Britain	1955	5 526	1.17
Sweden	1976	1 168	0.38
Sweden	1955	902	1.21
Spain	1976	4 759	0.74
Spain	1955	1 501	6.43
Portugal	1976	2 520	1.91
Portugal	1955	520	3.84
Holland	1976	2 432	0.59
Holland	1955	1 552	4.12
Italy	1976	8 927	0.51
Italy	1955	5 752	4.62
Eire	1976	525	0.85
Eire	1955	282	1.62
Greece	1976	1 063	1.42
West Germany	1976	14 978	0.74
Denmark	1976	857	0.53
France	1976	13 577	0.74
France	1955	8 058	1.92

/(Concl.)

(Concl.)

Country	Year	Number of deaths	Death rate per 10 <sup>3</sup> vehicles
Cyprus	1976	67	0.78
Cyprus	1955	86	5.31
Belgium	1976	2 488	0.82
Belgium	1955	828	1.29
Austria	1976	1 903	0.83
Austria	1955	1 485	7.13

Sources: "Statistical Yearbook of the United Nations", 1977 and 1979 editions. "Demographic Yearbook of the United Nations", 1977. "Statistics of Road Traffic in Europe", United Nations, 1977. "Diretrizes de Segurança de Trânsito", Ministério da Justiça, Brasília, D.F., 1978.

Table 7-2

DEATHS FROM SELECTED CAUSES IN CERTAIN LATIN AMERICAN COUNTRIES

Cause	Number of deaths in				
	Jamaica (1971)	Colombia (1969)	Peru (1970)	Brazil (1970)	Venezuela (1971)
Cholera	0	0	0	0	0
Typhoid	4	284	488	55	3
Bac. Dysentery, amoebiasis	1	595	154	129	315
Enteritis, etc.	688	16 356	10 227	10 598	5 085
Tuberculosis	66	3 240	5 079	3 743	1 058
Smallpox	0	19	0	3	0
Malaria	2	930	43	74	15
Syphilis, etc.	61	92	41	256	82
Other infective, parasitic diseases <u>a/</u>	255	4 840	2 946	3 690	2 474
ROAD ACCIDENTS	364	1 170	1 919	1 569	3 081
<u>Total</u>	<u>1 441</u>	<u>27 526</u>	<u>20 897</u>	<u>20 117</u>	<u>12 113</u>

Source: "Road accidents as a cause of death in developing countries", by Jacobs and Bardsley, Transport and Road Research Laboratory Report SR 277.

a/ Excluding plague, diphtheria, whooping cough, streptococcal sore throat and scarlet fever, meningococcal infection, acute poliomyelitis and typhus and other rickettsial diseases.

Table 7-3

## REPRESENTATIVE COMPOSITION OF EXHAUST GASES IN ENGLAND IN PARTS PER MILLION

Contaminant	Idling		Accelerating		Cruising		Decelerating	
	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
CO	69 000	trace	29 000	1 000	27 000	trace	39 000	trace
Hydrocarbons	5 300	400	1 600	200	1 000	100	1 000	300
NO <sub>x</sub>	30	60	1 020	350	650	240	20	30

Source: Sharp and Jennings, *op. cit.*, taken from "Air pollution from road traffic" by Sherwood and Bowers Road Research Laboratory Report LR 352.

Table 7-4

THE PERCENTAGE OF TOTAL POLLUTION WHICH DERIVES FROM TRANSPORTATION  
SOURCES IN CITIES IN LATIN AMERICA AND ELSEWHERE

City	Year	HC	NO <sub>x</sub>	Part.	SO <sub>2</sub>	CO
Los Angeles	73	90	75	50	12	100
Tokyo	73	?	69	5	4	?
Santiago, Chile	78	85	86	?	?	99
Buenos Aires	72	70	47	12	4	81

Sources: Various, including the report of CORFO-Chile "Programa para el control de la contaminación atmosférica en el Area Metropolitana de Santiago" as reported in several editions of "El Mercurio" of Santiago; information provided by the Subsecretaría de Estado por Obras Públicas y Transportes of the Republic of Argentina; papers presented at the 9th World Energy Conference, 1974, London.



Table 7-5

THE DISTRIBUTION OF AIR POLLUTION CAUSED BY MOBILE SOURCES  
SANTIAGO, CHILE BY VEHICLE TYPE

Vehicle type responsible for pollution	Percentage of emissions from vehicle type identified		
	Carbon monoxide (CO)	Hydrocarbons (HC)	Oxides of nitrogen (NO <sub>x</sub> )
Private cars	6.5%	5.5%	2.0%
Buses	40.9%	34.7%	66.8%
Taxis	51.2%	44.2%	16.0%
Total transportation	98.6%	84.5%	85.2%

Source: "Programa para el control de la contaminación atmosférica en el área metropolitana de Santiago. Recomendaciones, junio 78", as quoted in "El Mercurio de Santiago", Informe Económico, June 1979.

Table 7-8

PERCENTAGE OF VEHICLES OF DIFFERENT TYPES PRODUCING NOISE PEAKS OF  
85 dB(A) OR MORE DURING SURVEYS REALIZED IN ENGLAND  
IN COMMERCIAL STREETS

Type of vehicle	% in excess of 85 dB(A)
Motorcycle	6.01
Car and light truck	0.33
Medium truck	4.11
Heavy truck	42.68
Bus	6.23

Source: Transport and Road Research Laboratory Reports N° LR 586 and  
LR 603 as quoted in "Transport and the Environment" by  
Sharp and Jennings, Leicester University Press, 1976.

Table 7-9

A COMPARISON OF PERMITTED SOUND LEVEL ACCORDING TO ARTICLE 8 OF  
ORDENANCE AD 560.10 OF THE CITY OF BUENOS AIRES AND THOSE OF  
A TECHNICAL DIRECTIVE OF THE EEC OF FEBRUARY 1970

Type of vehicle	Maximum permitted sound level in dB(A)	EEC equivalent for same vehicle
Motorcycle up to 50 cc	75	74 <u>a/</u>
Motorcycle 50-125 cc	82	81 <u>a/</u>
Motorcycle above 125 cc	86	85 <u>a/</u>
Motor vehicle to 3 1/2 tons tare	86	83 (cars) 85 (trucks, etc.)
Motor vehicle above 3 1/2 tons	90	90/92 <u>b/</u>

Source: Information provided by Argentinian Subsecretary of Transport and Public Works and Sharp and Jennings, op. cit.

a/ Not part of EEC directive: as adopted by France in 1972.

b/ For trucks up to/over 200 bhp.

Annex 1

THE DETERMINATION OF STATISTICAL RELATIONSHIPS TO EXPLAIN  
CAR OWNERSHIP AND TO FORECAST OWNERSHIP RATES

As has been reported in chapter 2 of the text of the paper to which this is an annex, we developed statistical relationships, separately for the years 1950, 1962 and 1974, which associated car ownership per head with income, using the GDP proxy, per head. From these relationships the conclusions of chapter 2 and chapter 3 were drawn. This annex attempts to explain the derivation of the relationships used.

1. Introduction: some previous analyses to relate  
car ownership and income

It is quite obvious that income and/or wealth is a determinant of car ownership. Countries with high per capita incomes have higher rates of car ownership (in this paper we use as the definition of the rate of car ownership, the number of cars per thousand people) than do countries with lower incomes per capita. One may observe that car ownership seems to be higher in Venezuela than in Bolivia, in Australia than in Papua-New Guinea, or in the United States than in the United Kingdom. Wealth too may be seen to be an influential factor; for instance, in 1974 per capita income in the R.O. del Uruguay was about the same as it was in Brazil but Uruguay was even richer in per capita terms 24 years in 1950 and had built up wealth from its previous higher income a part of which was made manifest in the car ownership rate, which was higher than that in Brazil, a country which was very much poorer in 1950 than in 1974.

But quite obviously other factors are important. Amongst these may be enumerated the following:

- (i) The income distribution, as explained in section VI of the paper.
- (ii) Car prices and credit terms to the user, also as explained in chapter VI.
- (iii) Car operating costs, with gasoline being an especially well perceived item (whilst the costs of new tires, for instance, may not weigh heavily).

/(iv) The

(iv) The age structure of the population; clearly the young, because they are legally incapacitated, and the old, usually because they formed their way of living in a society less car-addicted than today, are less likely to own cars than are the other people.

(v) The degree of urbanization. Those who live in rural areas have a higher propensity to own a car since they have lower levels of accessibility by other means of transportation than those in towns; but note that in Latin America the tendency for the rural areas to house the less affluent may dominate the car rural-urban balance of ownership propensities.

(vi) Restrictions on car usage. Those who live in city centers may own fewer cars for this reason. In Singapore, car ownership was observed to fall in certain areas when strict limitations on city center car usage were introduced.

(vii) The state of the road system may have an effect; although this has not been statistically proven, at the limit it would be true (in that were there no roads there would be few cars).

(viii) The degree of accessibility by collective transportation; this effect is very difficult to identify statistically, although reason would dictate that it does have an impact.

(ix) The cultural acceptability of the automobile; this impacts in various ways sometimes raising ownership propensities, sometimes lowering them.

(x) The range of cars on the market; it is said that the introduction of new models stimulates demand and not always merely switches purchases to them from existing models.

Clearly to include all of these influences or even some of them, in any statistical attempt to explain car ownership would be fruitless. Even were data to be available there would be severe problems of autocorrelation. These difficulties have been appreciated by previous researchers in the field. The problem has more often than not been reduced to the development of associations between car ownership rates and income per head. Some attempts, especially in countries such as the United Kingdom where data availability is quite good, have incorporated other variables, such as an index of car costs to the user, with varying degrees of conviction.

/However, the

However, the reason for developing the relationships sought by the present research is essentially to identify those countries which have either higher or lower rates of car ownership than others on the basis of recognized, powerful, and readily available independent variables so that the impact of secondary influences, such as car prices or cultural factors, be facilitated once the association between the dependent variables and the chosen independent variables has been determined. The recognized most powerful influence is income per head. Thus we have attempted to relate car ownership rates with income per head, through the not necessarily perfect substitute of GDP per head (due the better availability of data on the latter), and, as it were, leave worrying about the secondary influences to afterwards. However, when making use of the relationships developed for the making of forecasts we do explicitly introduce an allowance for the age structure of the population, and implicitly for many other variables listed above.

Most previous attempts, to statistically explain car ownership of the relatively few which have been made, have been for the purpose of forecasting. One notable exception, however, was the analysis made for the CEPAL study "El transporte en América Latina" United Nations, New York, 1965. In this study a single constant elasticity relationship was developed between car ownership per person and the level of GDP per person using data for different years. Countries with greater or lesser rates of ownership were identified, versus the trend calibrated, and some discussion was entered into as to why they should so differ, in much the same way as we in this study had in mind. However, the utility of the previous attempt is seemingly limited by several methodological deficiencies, for instance:

(i) The relationship fitted assumed that the elasticity of car ownership with respect to GDP per head be constant, i.e., independent of the level of GDP per head. This may possibly be adequate at relatively low (per capita) levels, such as those of Latin America at that time, but the calibration was also over countries in Europe and North America. The calibrated function implies that were per capita GDP to be US\$ 4,000 then everybody, whether man, woman or child, would, on average, own one car. This is clearly not very reasonable.

/(ii) Although

(ii) Although the relationship is calibrated for both the year 1950 and the year 1960, the estimation procedure apparently made no allowance for inflation between these two years.

(iii) The calibrated function is biased to the extent that a country included for one year is not always included in the other year.

(iv) No allowance is made for the probability that car ownership may change through time at given income per head due to any trends not related with income, such as a change in the age structure or degree of urbanization.

(v) As we have had to do, GDP data were substituted for income data.

Thus, making an overall appraisal, one would conclude that this previous attempt was not generally reliable although probably adequate for the making of the conclusions that its authors actually derived from it.

A further United Nations study which has developed statistical relationships between product levels and car ownership was "The Motor Vehicle Industry", prepared by UNIDO and published in 1972. Unfortunately this attempt seems even less trustworthy than the one referred to above, although the methodology used is inadequately described in the report published thus, prohibiting making a complete appraisal. The objective of the exercise was to forecast car ownership. Amongst the deficiencies which this attempt seems to have enveloped are:

(i) It is claimed that the observed points show that the relationship between vehicle ownership and GDP per head be linear (by region of the world) whilst the graph plotting such data points indicates otherwise; all points between those with extreme "x" axis values are either on or below a line joining the two extreme values.

(ii) The graph referred to in (i) was with respect to vehicle ownership rather than car ownership. The authors, over and above wrongly interpreting the relationship as being of a simple linear form, also interpreted that the same linear form relates car ownership and GNP (which was used rather than GDP).

(iii) One sentence in the published report states "A similar observation (that the relationship between cars per person and per capita GNP be linear) was made in 1960 by Hondermanmarcq, Director General of Bridges and Roads in the Belgian Ministry of Public Works, though in terms of the logarithms

of the two functions". A further sentence on the same page reads "If each set of projections is confined to the countries in a geographical area, natural, rather than logarithmic functions may be used, owing to the fairly small differences in per capita GNP". This indicates that the analyses encountered some problems of nomenclature and would have ignored that GNP per capita was considered to increase through time thereby rendering the fact that present GNP be deemed to be of restricted range within any one geographic area (which is of doubtful validity anyway) of dubious utility.

There seem to be serious deficiencies with the projections made by UNIDO due to methodological difficulties in the development of the forecasting equations and it is not clear that the statistical analyses were adequate for the use made of them.

A very interesting and exhaustive report of the methodology used for the projection of car ownership rates by the Transport and Road Research Laboratory of the United Kingdom, itself based on many years of development and study of similar investigations being undertaken elsewhere, is found in the "Journal of the Royal Statistical Society, Series A", volume 141, part 1, 1978 under the title "Long-term forecasting of vehicle ownership and road traffic" presented by J.C. Tanner. The sophistication of the procedures used in the United Kingdom is permitted by reasonably good data availability and stimulated by the criticisms which have been made of fleet size forecasts by the environmental lobby, which is aware of the importance of such forecasts in the economic evaluation of highway schemes. Much of Tanner's discussion is of little immediate relevance to the present paper since we have no chance of obtaining as much basic information as Tanner had available to him, but nevertheless the paper does provide some pointers to direct the type of procedure used.

The Transport and Road Laboratory (TRRL) used for many years a projection equation of the following form:

$$\text{Vehicles per person} = \frac{\text{saturation level of vehicles per person}}{1 + a e^{bt}} \quad (1)$$

in which "t" denotes the year to which the data point applies. It came to be realized by the TRRL that a function of the form of (1) may not be

/reasonable insomuch



reasonable insomuch that it is symmetrical about an inflexion point, and, thus, that the growth pattern implied was such that it would take the same number of years to attain 50% of the saturation level of ownership as it would do to reach 100% from the 50% point. The available information would seem to infer that the latter period be the longer. The TRRL analyses used time series data, rather than cross-sectional analysis.

We have accepted the TRRL's point that the curve should more rationally be non-symmetrical in that the change in "x" axis value to the inflexion point from the point where "x" equals zero should be less than the change in the "x" value from the inflexion point to where the saturation level of ownership is closely approximated. But we diverge from Tanner's other guidelines in several ways. Firstly, we have not included some of the sophistications which Tanner invoked, which can be said to be overmuch for even his case. Secondly, we chose to use cross-sectional data over a number of countries rather than time series analysis, due to the nature of our problem. Thirdly, and hence, we used a proxy for income per head, rather than time as the independent variable.

The TRRL work is a sophisticated version of others which have been conducted in various parts of the world. The present author has used basically the same procedure in New South Wales (Gosford) and Malaysia (Kuala Lumpur) for instance. Nevertheless the methodology is arguably inadequate for the projection of fleet size were it not to treat the importance of operating costs and limits on the usage of cars in a behavioural manner, which has not really been enveloped by analyses to date. On the other hand, were it to be applied for several years separately using cross-sectional data, the secular change in the position of the curve could describe the effect of changes in such explicitly excluded variables.

## 2. The development of the relationships

The basic data is shown in table 2.1 of chapter 2. It embraces, for each of the three years examined, 27 countries in all, both within the Latin American Region and elsewhere. The inclusion of countries elsewhere was so that the functions be adequately defined in the high income range, beyond the levels attained in Latin America, but, hopefully, to be reached

/in the

in the not-too-distant future. Were such non-Regional countries not to have been included one would not have been able to have had much confidence in the position of the curves implied by the relationships at the GDP levels of the richer Latin American countries, such as Argentina, Venezuela and Uruguay.

The form of the function fitted was, after some experimentation, the same in each of the three years considered, these being the evenly-spaced one of 1950, 1962 and 1974. The form was,

$$\text{cars per 1 000 persons} = \frac{\text{saturation level of cars per 1 000 persons}}{1 + aY^b} \quad (2)$$

where Y is per capita income in 1970 US dollars.

The calibration was performed separately for each of the three years to allow for the possibility that between each successive pair the expected number of cars owned at given real income change, due to a wide variety of possible causes, such as those listed at the beginning of this annex; for instance through the passage of time, and independent of the influence of real income, car ownership probabilities may change due to gasoline prices falling, as they did in real terms from 1950 through 1972 (net of taxes). It was hoped that an analysis of any difference in the curves calibrated for the different years would give an insight into the effect of such secular change in car-ownership propensities, and perhaps an indication of which factors were the more important. GDP was chosen as the independent variable in the calibration exercise since it was much more widely available than income measures, which would have been preferable.

The GDP data was obtained from "Series Históricas del Crecimiento de América Latina", CEPAL, Santiago, Chile 1978, for the countries of the Region. For the other countries embraced in the calculations data was assembled from various editions of the U.N. Statistical Yearbook, generally by adjusting the 1970 GDP per head data by indices giving changes in GDP per head for other years relative to this base year. The car ownership data was generally derived too from the U.N. Statistical Yearbook. For some countries the information on car ownership is not consistent throughout the 1950 to 1974 period, due to corrections of series, redefinition of what constitutes a car, as opposed to a light truck (for instance), etc. In such

cases, to the extent that was possible, the data for previous years was corrected to the 1974 definition.

It was found that the type (2) equation provided an adequate fit for each of the three years, but that the type (1) form was acceptable for 1950, when the car ownership of most countries were severely distorted still by the after-effects of the second world war. Nevertheless we chose to rely on the type (2) form for all three years to provide consistency for the inter-temporal comparison.

The calibration exercise differed in one important respect from some previous attempts at the same kind of problem, for instance those conducted by the English TRRL. In such previous studies the saturation level of ownership was determined exogenously by, for example, studying ownership rates in states of the United States and countries of the United Kingdom in an attempt to plot ownership rates against income per head for a wide variety of areas so that the trend may be extrapolated to yield an estimate of the saturation ownership rate at very high income levels, as yet unattained either in the United States or the United Kingdom. In our calibration exercise we treated the saturation level as an endogenous variable. Generally, we followed the procedure of assuming a particular low saturation level (for each year) and then deriving the best fit values for "a" and "b" of equation (2) given this assumed saturation level. The value of " $r^2$ " was noted for this assumed saturation and the best fit parameter values. Then the saturation level was increased to a higher level and the process repeated. The chosen saturation level was that determined by the equation with the highest value for " $r^2$ " over all the combinations of best-fit values of "a" and "b" and saturation levels considered. The saturation level was increased for each year until the best-fit equation calibrated assuming it started to decline.

This procedure gave saturation levels of car ownership which are high by the standards of previous attempts by other researchers. For instance, the best equation for 1974 implies that the saturation level of car ownership is 900 cars per 1 000 persons, which would be close to being reached were GDP per head to be US\$ 213,000 in 1970 prices. The saturation level thus has academic value only since it is very unlikely that any significant area

of the planet on which we live ever attain such a degree of affluence. It is worthwhile to consider why the saturation level, so derived through a procedure which should result in the level of saturation which best conforms to the facts, be so high. One reason is certainly the tendency for those countries with the higher GDP per head figures to have lower birthrates and societies more used to car-using lifestyles so that even relatively elderly people are not adverse to car ownership. Thus the proportion of the population legally and physically able to own a car would be an increasing function of GDP per head. Use of the equations calibrated far away from the range of GDP values over which they were estimated would probably infer that the percentage of people physically and legally entitled to own a car exceed one hundred. (The forecasts given in chapter 3 of the paper, and explained in this section, make allowances for such variation in the structure of the population as a function of GDP per capita.) One would anticipate that, were the equations to have been developed for car-ownership per member of the population between the ages of 15 and 75, the saturation levels deduced would have been more acceptable to the superficially critical eye.

The equations found to best fit the data were:

For 1950,

$$z = \frac{800}{1 + 19\,032\,352 Y^{-1,895654}}, \quad r^2 = 0,843 \quad (3)$$

and for 1962,

$$z = \frac{900}{1 + 5\,890\,013 Y^{-1,793771}}, \quad r^2 = 0,925 \quad (4)$$

and for 1974,

$$z = \frac{900}{1 + 5\,224\,080 Y^{-1,814877}}, \quad r^2 = 0,977 \quad (5)$$

where, "z" represents the number of cars per 1,000 persons, and Y denotes GDP per capita in 1970 United States dollars. In each case n = 27, the same 27 being used throughout. The countries are identified in table 2.1.

Although the equations were developed essentially for the purpose of analysing the tendencies in car ownership by country and through time over the period since 1950, they can also be used for forecasting. The first

/problem encountered

problem encountered when utilizing the work conducted so far for forecasting is which equation to use. We have a choice from three, or alternatively we may use some combination of them. The one for the year 1950 may be disregarded since it refers to a hopefully unusual situation in the history of the world when a recovery was being made from devastating war. The equation for 1974 implies higher car ownership levels at any income between zero and infinity than the one for 1962, thereby indicating a raising of car ownership propensities through the intervening period. One may assume that the change in the propensity to own a car at given income as occurred from 1962 to 1974 increase at the same secular rate into the future. This would imply that the joint impact of changes in car prices, running costs, the income distribution, etc., be in the future as it was in the past. This may not be considered reasonable.

Changes occurred regarding variables when influence car ownership in the period 1962 to 1974 that may never again recur with the same intensity. The period of steadily declining fuel prices is probably forever behind us; car prices generally fell from 1962 through 1974 due to the reaping of scale economies on a degree that may not be possible in the future; many cities in Latin America, and also to some extent elsewhere adopted policies of catering for the car during the 1962 to 1974 period, and may never do so again, etc. So, alternatively, it may be that the projections of ownership should assume that the propensities to own cars at given income levels of 1974 remain at the same values to the end of the forecasting period. It may even be reasonable, for the purposes of the projections, to assume that the tendency for car ownership at given real income to increase, as it did in the past, to reverse itself in the years to come. However, since we have no objective means at our disposal of determining to what extent such reversal may occur, we have not made any projections based on this premise.

Both sets of forecasts, both that which takes as fixed for the future 1974 propensities of own cars at given income and that which assumes that such propensities continue to increase at the same annual rate as they did from 1962 to 1974, were made on the basis that a country which in 1974 had a GDP per capita (in 1970 US dollars) of "x" maintain into the future the

/proportion of

proportion of its population in the age-group where car ownership is concentrated, taken for analysis purposes as being between 15 and 75, as it had in 1974, rather than take on the population structure of countries which in 1974 had GDP per head levels equal to what the country concerned will have in the future. The making operational of this assumption required that the relationship between the percentage of the population aged between 15 and 75 and GDP per head, in 1974, be established. Using data for a variety of countries obtained from the United Nations Statistical Yearbook, it was deduced that,

$$D = 2,9684 + 8,4387 \log Y_{74} \quad (6)$$

where "D" is the percentage of the population aged between 15 and 75. Figure A.1.1. plots the observed data points in relation to this fitted curve. It is admitted that were more exhaustive analysis to have been made, the coefficients of the equation may have been slightly different from those derived.

Thus, on the basis of the above discussion, it was derived that, were car ownership propensities at given income to remain to their 1974 levels, the forecasting equation should be,

$$z_t = \left[ \frac{900}{1 + 5\,224\,080 Y_t^{-1,814877}} \right] \left[ \frac{2,9684 + 8,4387 \log Y_{74}}{2,9684 + 8,4387 \log Y_t} \right] \quad (7)$$

$$= \left[ \frac{900}{1 + 5\,224\,080 Y_t^{-1,814877}} \right] \left[ \frac{\log (1,421568 Y_{74})}{\log (1,421568 Y_t)} \right] \quad (7a)$$

where,

- $z_t$  is car ownership per 1,000 persons in year "t"
- $Y_t$  is GDP per capita in year "t" in US\$ of 1974
- and  $Y_{74}$  is GDP per capita in year 1974 in US\$ of 1974.

In the case where the annual changes observed from 1962 to 1974 in car ownership propensities at given real per capita income continue into the future, the first term of equation (7a) comes to,

$$\frac{900}{1 + 5\,890\,013 - 55\,494,42 (t - 1962) Y_t^{-1,793771 + 0,00175883 (t - 1962)}}$$

whilst the second term, which deals with the impact of the age structure, remains as in equation (7a). The forecasts of chapter 3 were based on the /equations presented

equations presented above. The GDP per head forecasts, needed as independent variables, were taken from the forecasts of GDP to 2,000 AD of the Centro de Proyecciones Económicas de la CEPAL whilst population projections are the "trend" population estimates of "Boletín Demográfico" year XI, number 22 of CELADE.

The estimates of the income elasticity of car ownership with respect to income per capita tabulated in chapter 2 were derived by manipulations of equations of the type (7a), for each year separately. Thus the elasticities too assume that as the income per capita of a country increases there is no accompanying change in the structure of the population. Therefore they refer specifically to changes in income rather than being affected by any evolution of the demographic and social structure of the population, which influences would only serve to distort the elasticity measures were they to be included. The elasticities were derived from the following formula, using the case of the year 1974 as an illustration:

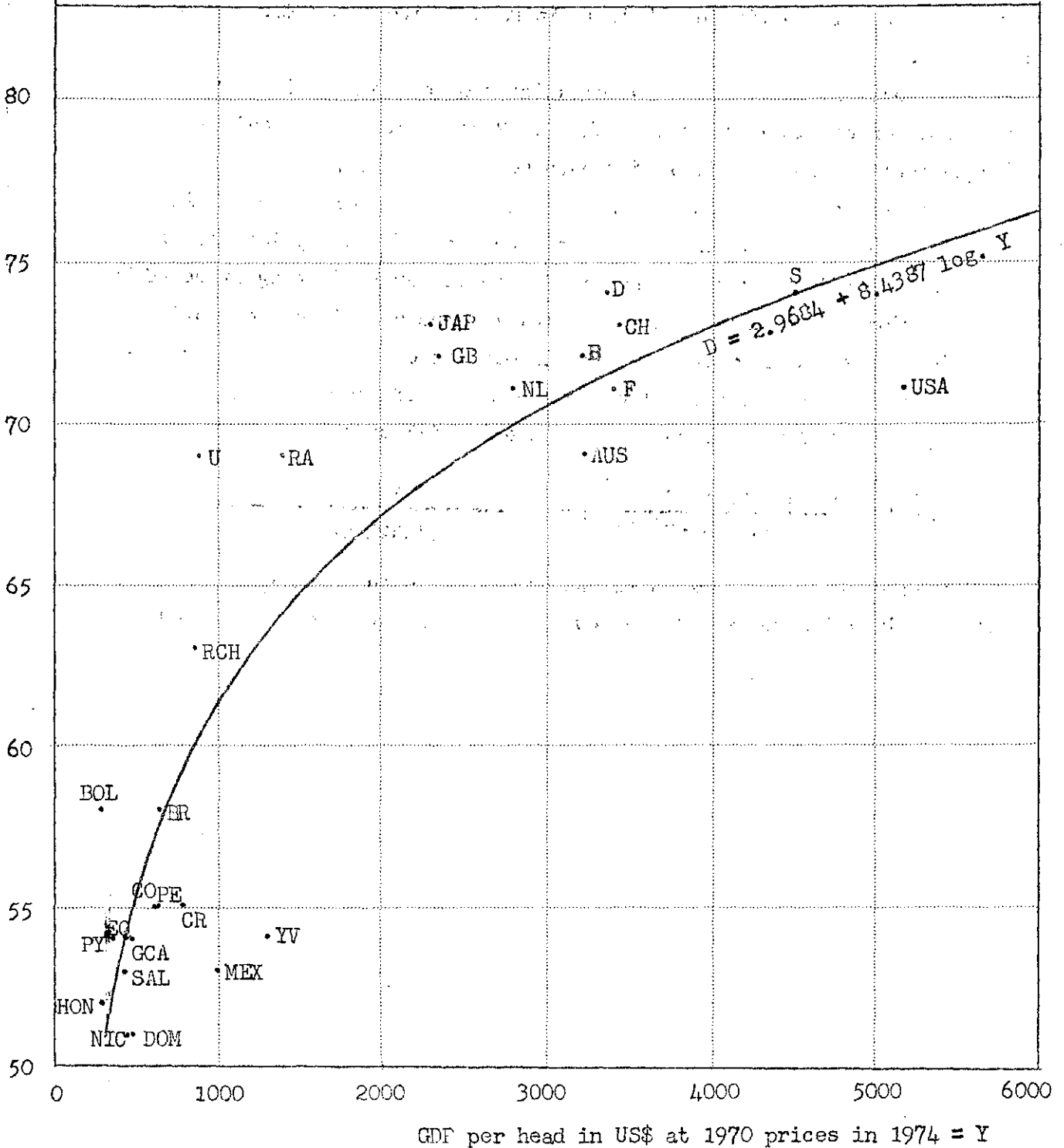
$$e_{1974} = \frac{9\,481\,063 Y^{-1,814877}}{1\,5224\,080 Y^{-1,814877}} - \frac{1}{\log(1,421568 Y)} \quad (8)$$

The equations for the years share the same form, with the parameters differing in value to reflect the equations calibrated for these other years.

Figure A.1.1.

RELATIONSHIP BETWEEN % OF POPULATION BETWEEN AGES OF 15 AND 75 AND GDP PER CAPITA IN 1974 IN US\$ PER COUNTRIES EXAMINED.

% population between ages of 15 and 75 = O





Annex 2

A SUGGESTED METHODOLOGY FOR THE QUANTIFICATION OF THE BENEFITS AND COSTS  
OF THE PRIVATE AUTOMOBILE

1. Introduction

As far as the author is aware, there has never been any attempt anywhere to derive benefit: cost relationship for the private car, treating it as an investment project, not even in a conceptual manner. In view of this it is perhaps, at best, surprising, and at worst, alarming that the private car has so often been singled out as a social evil whose impact on civilization should be minimized. There has been an overconcentration on the social costs associated with the automobile. Sometimes there is admission that these costs are accompanied by benefits, largely to the user, but there is no attempt to estimate the magnitude of such benefits.

It is true that the estimation of the benefits which derive from the private car is not easy in practice, and even presents considerable conceptual difficulties. Were there to be fewer difficulties with such estimation then presumably somebody would have made an attempt at such estimation. In this appendix 1/ we suggest a methodology, albeit on a very sketched form, which is considered to be implementable in practice, in some cases without any recourse having to be made to newly acquired survey data. It would be very interesting indeed to have had the opportunity to work through the proposed methodology for at least one Latin American country with good data, such as Brazil, but unfortunately during the present study there has been insufficient time to permit this. The procedure could be used on an iterative manner to determine that level and distribution of car ownership which optimizes welfare.

2. The estimation of user benefit from automobile usage as a function of the level of such usage

The type of vehicle considered in this annex, the private car, is generally owned by families, the members of vehicle travel. Their most worthwhile trips could be made even without a car being available, even though the availability of a car considerably increases the convenience of travel. It is noticeable, as

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1/ The methodology is illustrated on outline form as figure A.2.2.

/shown in

shown in chapter 6 of the paper to which this is an annex, that the availability of a car to a family results in the generation of trips that would not otherwise have been made, independent of income levels and other considerations.

When a car is acquired, it may be thought of as, in the first instance, being used instead of walking, taking the bus, or whatever, in accomplishing the same trip making pattern as was carried out in the days when no car was available. In reality, the car would tend to cause a change in trip making patterns through, for instance, stimulating the transference of the population from inner areas to the outer suburbs. But we shall err on the conservative side regarding the benefits from the car and consider the situation before the family has been able to react to take full advantage of the opportunities that the private car provides.

The benefits that the users of cars derive from such use instead of collective forms of transportation, or walking, are expressible as the difference in the user cost of the given amount of trip-making via car versus by the initial mode. Figure A.2.1. expresses the derivation of such benefits graphically. For successive increments in the kilometrage performed by the car, the difference between the user cost via the previous mode of transportation and the user cost by car can be envisioned as declining monotonically, per kilometer, considering that the first kilometers traversed by the car substitute for the relatively most inconvenient trips previously made by the other modes. In the diagram the car is shown as being used for  $Oq_0$  kilometers (per week or whatever other time period) instead of the previous means of transportation. Even the last few kilometers substituted by the car for other means of transportation show a considerable net benefit from the substitution to the trip-maker. Note that in the calculations it would generally be necessary to recognize that trips by car may cover more, or less, distance than the equivalent trip when it was made by other means.

However, as we have pointed out in section 6 of the paper, the car results in more trips being made and more kilometers being covered, than in the case when no car was available. The way in which it is proposed to measure the benefits from such extra trip-making is also illustrated in figure A.2.1. It may reasonably be assumed that a family which acquires a car (or more correctly acquires the use of a car) covers more and more vehicle-kilometers

/in it

in it until the next vehicle-kilometer would not result in any (perceived) net worth to the members of the family. Thus the last kilometer run (per week or whatever) can be associated with zero net perceived benefit (although maybe a positive, or alternatively a negative benefit were some costs to be incorrectly perceived). One may trace a curve, as done in the diagram, between the last known benefit per vehicle-kilometer, that associated with the  $Oq_0^{\text{th}}$  kilometer, to the last kilometer run by the car in the week, i.e., the  $Oq_1^{\text{th}}$  kilometer. The curve may reasonably, maybe, be assumed to conform to an extrapolation of the implied form between "x" equals 0 and "x" equals  $Oq_0$ . It may be possible to trace the exact form of the curve in specific instances through studies to determine the revealed preference structure of the trip-makers.

The basic principles described in the above paragraphs, should be qualified in a few respects. Firstly, there would need to be adjustments to the calculations in recognition of the fact that, in general, car users do not act as if they knew the full marginal costs of their decision to travel. They may recognize, for instance, only the tax-inclusive fuel costs, which, over and above not reflecting the true opportunity cost of the fuel consumed, ignores the extent to which marginal travel results in tire wear, maintenance costs, and so on.

Secondly in the case of a multi-car family, the same basic type of analysis should be conducted separately for each extra car, noting that the second car may, to a certain extent, replace the use of the first car resulting in extra convenience; for instance the lady of the house may not have to drive her husband to the commuter railraod station or to the office every day, instead of leaving him to drive himself whilst remaining with the second car for her own use. It would be possible through specific observation of case studies to place a monetary value on such extra convenience, and in some instance existing data may be adequate that such estimates be made without recourse to further surveys.

/Thirdly, the

Thirdly, the benefits per family by type of family (as varying by geographic location within the country, structure, and so on) must be aggregated to yield an estimate of the total user benefit for the whole nation being examined. It may be important to give due consideration to the probability that the first families to acquire cars be those which would make the greatest use of private transportation, although the degree of affluence of the household is obviously too a factor influential in the decision to acquire or not to acquire a family car. (The desirability of categorizing families by income is thus clearly indicated.)

Finally, since it would be a prime object of any investigation realized along the lines suggested in this appendix to determine the optimum amount of car ownership for a country in a given context, it would be necessary to determine the total user benefits for varying total levels of car ownership. This would require that relationships between the total amount of car ownership in the country and the number of families in each type owning cars be developed. It may be assumed that any attempt to ration car ownership be on the basis of price, in which case, for each type of family, it would be necessary to develop functions relating car prices with the proportion of the total number of families in the category which would own varying numbers of cars. This may be very difficult to achieve. Were time series data to be available on car ownership levels by type of family it may be possible to develop robust relationships between total car ownership and the proportion of households of each type that own various numbers of cars. This aspect of the methodology may be considered to be the weakest link in the chain. The existing work which has been carried out in this general area has been devoted principally to the estimation of the variation of car ownership by type of household as the overall family income level changes. It may be difficult to translate the relationships deduced in this way into a form which would relate car ownership to policy variables which may be used to control car ownership levels, such as taxes which affect car prices and registration fees.

### 3. The costing of the external effects of car operation

The estimation of the private costs of car usage and ownership is relatively straightforward, even were such costs to be expressed in social terms, i.e., the opportunity costs to the nation concerned acknowledging the preference structure of the society concerned. More difficulties are associated with the determination of non-private costs of car usage, and to some extent acquisition. Such costs are the consequences of actions unaccounted for by the user. For instance the car user takes no account of the congestion he forces upon others, unless he be unusually socially responsible. Some of the problems associated with the quantifying of such external costs derive from the estimation of the physical magnitudes involved rather than from the development of unit costs to apply these magnitudes, although the latter are not necessarily always well-defined either, and especially so in the field of pollution. In the case of private costs, i.e., those naturally recognized in the car user's accounting calculus, the physical magnitudes are well known as a result of engineering investigations; for instance, one knows with a good degree of confidence how much tire wear will follow from the operation of a certain type of vehicle on a certain type of road at a certain speed for so many kilometers. What is much more difficult to quantify is the extent to which the introduction of one extra vehicle to a traffic stream forces extra tire wear on other vehicles through disrupting the traffic flow to some marginal degree.

The first stage in the estimation of the external costs of car usage would be the allocation of car ownership to specific regions, distinguishing between cities and rural areas, probably as a function of relationships of car ownership with income level and of income level with geographical area. Some of the analyses necessary for this task may already have been realized in the tasks of section 2 of this appendix wherein car ownership propensities are determined by family type. The ultimate objective would be the estimation, for differing sizes of the overall car fleet, how many cars would be concentrated in each area.

/The assignation

The assignation of cars to areas by ownership would then be used to derive distribution of car usage by areas through a knowledge, partially published by surveys for transportation studies as a matter of course, and more thoroughly available from the analyses of such studies in an unpublished form. The output from this stage would be a listing of private car-kilometers by geographical area.

The impact in terms of external costs of any one car-kilometer would vary according to where this car-kilometer were to be performed. For each area one would define relationships between the volume of car travel and the mean speed of all traffic, recognizing that each extra unit of car travel slows down the traffic stream and thereby forces extra costs on society in terms of delays and higher vehicle operating costs. The required relationships have been developed for highways in a number of areas in Latin America. One should take note that the traffic speeds calculated in this operation affect the costs of private car travel in a way that may cause a revision of the user benefits referred to in section 2 of the appendix. Accident rates have been found to vary with a variety of factors, but are often expressed for simplicity as being dependent on the type of roadway and its location. Hence, in a manner as sophisticated or as simple as the data may permit it would generally be possible to determine accident rates per car-kilometer for each area thereby allowing the estimation of social costs of accident per kilometer travelled. A third type of external cost considered to be important is that of the various types of pollution, i.e., air contamination, and noise and others. Whilst it is possible to estimate the physical magnitudes of such pollution generated by each car-kilometer in each area it is impossible at the present stage of evolution of the necessary arts to unambiguously place monetary values on such costs.

Nevertheless, by such principles it is possible to place some kind of estimate on the external costs of congestion, accidents, and, maybe pollution, on each car-kilometer in each area into which the country has been divided. Multiplication of the unit costs so derived by the quantities of car-kilometers per area results in the total cost due to externalities, per area. Summing over areas results in estimated total external costs for the nation, which total may be calculated for varying levels of total car ownership.

/There is

There is another type of cost, which in most cases would have a negative value, which may be classified as an externality but which may be estimated in more direct manner. Such costs are the difference between the resource cost to the nation, and the cost to the user of car operation. On gasoline, especially, but also on other components of car operation, the user usually pays indirect taxation. Each kilometer travelled results in a transfer of resources from the traveller to the government which imposes the tax. Thus each such kilometer results in a benefit to the community as a whole through the intermediary of the government over and above the private gain through the trip concerned being made to the user, which benefits should be offset against the external costs of congestion, pollution and accidents discussed above.

#### 4. The estimation of the costs of car acquisition

Cars may be either produced locally, assembled locally from, to some extent, imported parts, or imported fully made up. In each case the cost to the nation of the acquisition may be estimated starting from the base of what the buyer pays for his purchase. Adjustments generally have to be made to such purchase prices so as to fully reflect opportunity costs.

Where the vehicle be produced locally, any direct sales taxation would not be part of the cost of the vehicle to the nation. On the other hand some of the ingredients which make up the car may be assessed in the final price to the user at values different from those which reflect opportunity costs to the nation. The opportunity cost of the labour involved may be less than the wages paid on account of the low productivity of alternative work. On the other hand the capital invested in the sector may have had valuable alternative usage were it to have been invested elsewhere to an extent greater than that reflected in market discount rates.

Were a vehicle to be partially or completely imported, any import duties should be extracted from the sale price so as to approximate to the opportunity cost to the nation. After having done this the import price in foreign currency should be converted into local currency using a shadow rate of exchange which may or may not be well reflected by the commercial exchange rate. Further adjustments of the kind mentioned in the previous paragraph may be necessary were there to be local assembly.

/5. The

5. The optimization of the level of car ownership

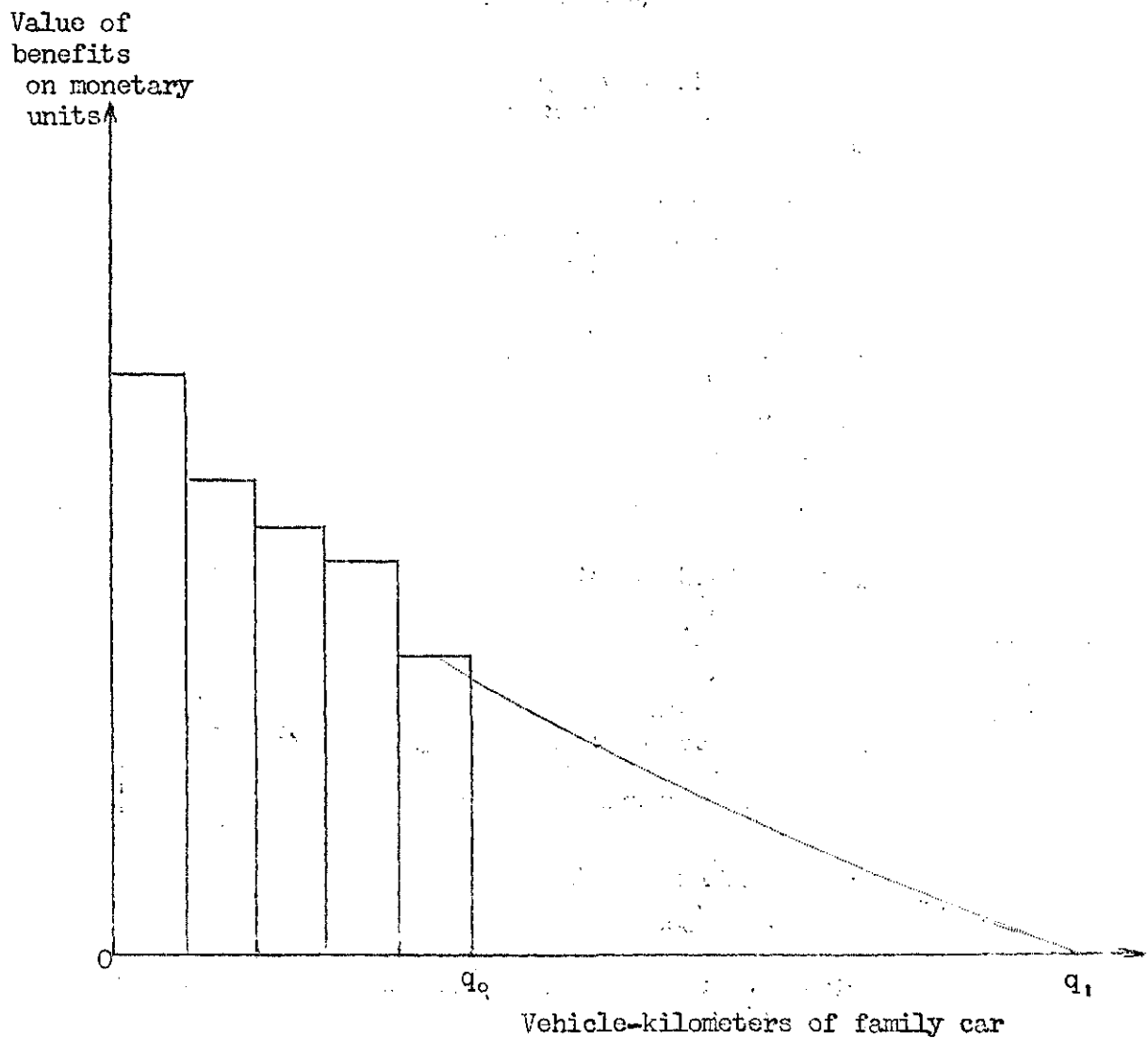
This would be achieved via the comparison of the net benefits, basically user benefits less the external costs of usage, with capital costs, i.e., the opportunity costs of the cars themselves, at different levels of total car ownership. The best level of ownership would be that which results in the greatest excess of benefits over costs. The comparison would follow the normal rules of benefit: cost analyses.

The analyses would also furnish extra information of a type extremely useful in planning private transportation. Especially important would be indications of where car ownership should be concentrated so that the environmental consequences of any given total amount of car ownership be reduced to the minimum level compatible with other social objectives.



Figure A.2.1

TO ILLUSTRATE DERIVATION OF USER BENEFITS FROM PRIVATE CAR

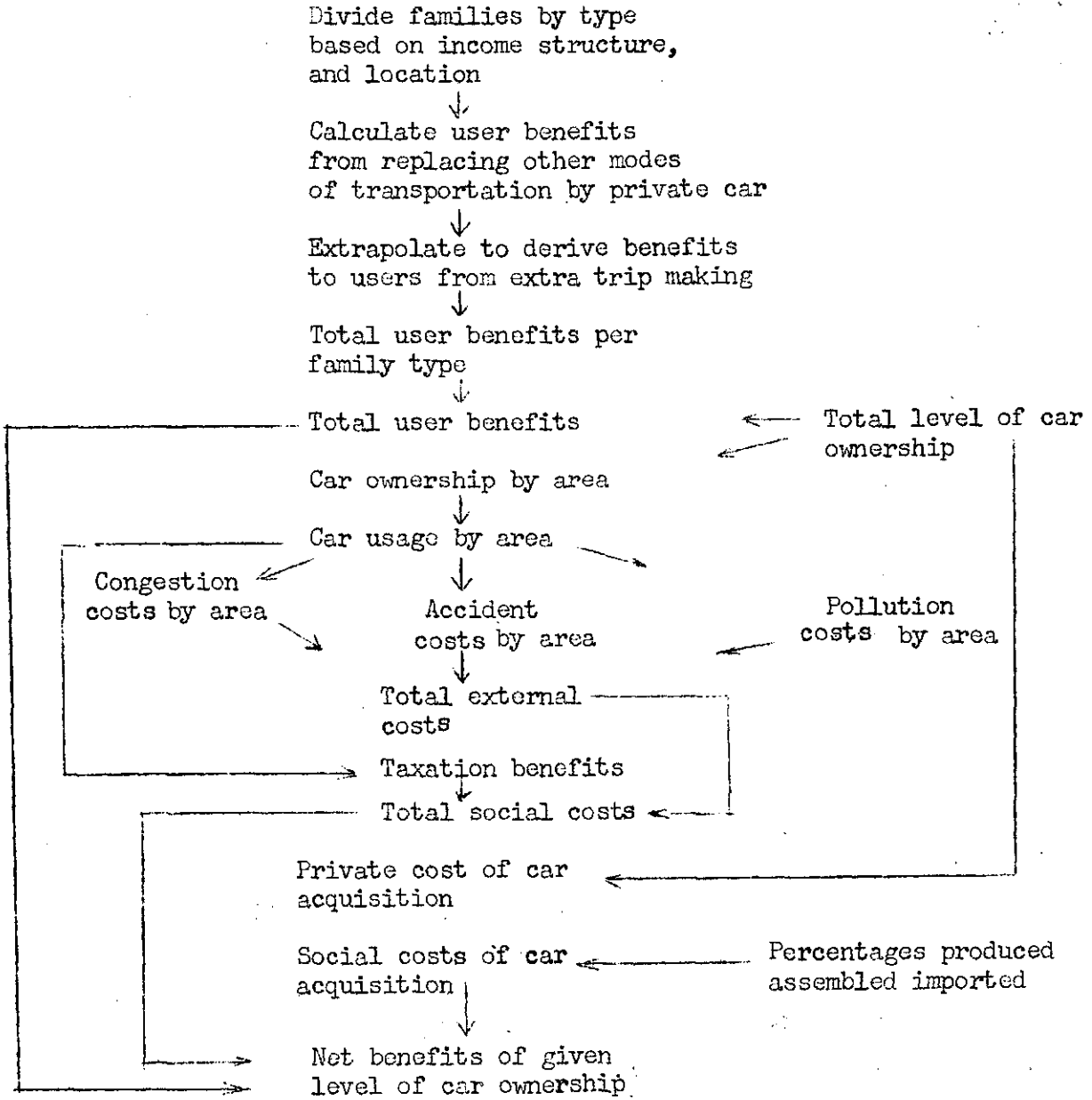


$Q_{q_0}$  = quantity of vehicle-kilometers by car in replacement of walking or collective transportation, per time period

$Q_{q_1}$  = total number of vehicle-kilometers performed by car during time period

Figure A.2.2.

THE INTER-RELATIONSHIP BETWEEN THE VARIOUS TASKS  
COMPRISING THE OVERALL PROPOSED METHODOLOGY



PRINCIPAL WORKS OF REFERENCE LISTED BY SECTION \*

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5. The motor vehicle industry, UNIDO, United Nations, New York, 1972.
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Section III

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Notes:

- (1) The list shown is not complete, rather it cites the works used most frequently during the preparation of the report.
- (2) Often, a reference was used for more than one section of the report. In such cases, the reference is listed once only, under the heading of the first section, ordered numerically from the lowest, in which it was used.
- (3) Much information was obtained personally from various organizations, notably: Secretaría de Transportes y Obras Públicas del Ministerio de Economía de la República Argentina; Ministério da Justiça do Brasil; GEIPOT, the State transportation planning organization of Brasil; Pesquisa e Planejamento de Transportes do Estado de São Paulo; Empresa Brasileira dos Transportes Urbanos; Empresa Metropolitana dos Transportes Urbanos de São Paulo; Fundação Getúlio Vargas; etc.