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ENERGY AND TRANSPORT IN BRAZIL

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This work in progress is issued with the dual purpose of informing the policy community of the state of knowledge and of eliciting comments on our efforts. The views expressed in this paper are those of the author alone and should not be interpreted as representing the views of either A.I.D. or Resources for the Future.

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Chapter 1

INTRODUCTION

The purpose of this paper is to examine the history of energy use in Brazilian transport in order to better understand energy use policy choices today. This has proved to be a difficult task given the complexity of the field and the frequently ambiguous, not to mention dubious, quality of much of the information. With regard to the crucially important road freight sector, the situation has been summed up by adapting a Churchillian witticism--"51 percent of the statistics are deductions, 49 percent are approximations; the rest are perfect" [1]. As partial compensation, Brazil is fortunate to have an excellent trade journal, Transporte Moderno, which is heavily relied upon to ferret out important clues in the puzzle. Though many pieces remain unfitted, it is possible to make some important generalizations.

If we survey the experience of Brazil during the 1970s at the most aggregate level--energy for transport (E_T) in relation to Gross Domestic Product (GDP), a rather surprising and important conclusion emerges. Comparing the period 1969-1973 with the period 1974-1979 the ratio of $\Delta E_T/\Delta GDP$ (either for all transport or surface transport alone) remains the same. There is some uncertainty in the numbers (no trustworthy historical official time series exists--see appendix A), but, if anything, the probable error is to underestimate transport energy use in the second period relative to the first. The conclusion we are driven to is that, at the margin, there was no improvement in the overall transport energy intensity of the economy. It can be argued that over the 1973-1979 period there was no coherent policy to promote energy conservation in transport, yet the government did substantially increase the price of gasoline and drastically shift priorities in transport infrastructure. If these measures had negligible impact, are we to conclude that there is little practical potential for energy conservation in transport?

This stable relationship is the outcome of many offsetting factors. If we examine these factors, it appears that the $\Delta E_T / \Delta$ GDP relationship will begin to fall, and that the extent of this fall can be heavily influenced by government policy. The potential appears to be considerable, though to fully reach it may require some shift in government priorities.

During the second half of the decade (1974-1979) a number of trends occurred which should have contributed to a decline in the $\Delta E_T / \Delta$ GDP ratio. These trends were:

a. A slowdown occurred in the growth of the automobile industry relative to GDP. In the first period (1969-1973) new car production increased at twice the rate of GDP. By the end of the second period it was less than the rate of GDP growth.

b. New cars produced were more efficient at the end of the period than at the beginning. A preliminary analysis suggests about a 10 percent improvement.

c. There was a shift to radial tires on cars, which should increase efficiency.

d. Medium and light trucks shifted to diesel from gasoline motors on a significant scale due to a shift in the relative price of the two fuels. In 1974, 30,000 medium and light gasoline trucks were produced in Brazil. By 1978 this had fallen to 1,000 (see table 1-1). Diesel engines are more efficient than gasoline, and this should have contributed some saving at the margin.

e. There was a modest trend towards larger trucks, which are more fuel efficient (see table 1-2). Relative to the pre-1974 period average intercity truck capacity may be 20-25 percent higher with perhaps a 10 percent greater fuel efficiency.

In addition to these changes there may have been a modest decline in the intensity of car use due to higher gasoline prices, weekend closure of gas stations, increased tolls, 80 kilometer-per-hour speed limits, and so forth.

Despite these favorable trends, fuel for transport increased in step with GDP. What were the countervailing factors? First, it takes time for a sharp slowdown in the growth of new car production relative to GDP to be

Table 1-1. Production of Cargo Vehicles in Brazil, 1968-1981

Truck type	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	through 1980	August 1981
Heavy	2,245	2,683	2,390	2,912	3,213	4,137	6,702	8,569	11,042 (10,926)	13,525 (12,723)	9,850 (9,982)	7,257 (7,263)	9,246 (9,384)	5,613 (5,537)	6,760 (5,343)
Semi-heavy	--	31	2,824	4,701	4,806	5,521	7,834	12,951	15,663 (15,779)	22,452 (21,187)	19,567 (20,932)	19,741 (20,091)	23,891 (23,340)	14,283 (13,976)	18,436 (17,373)
Medium--diesel	16,117	16,520	15,819	14,819	19,588	25,257	25,441	28,564	35,360 (34,870)	45,668 (44,725)	36,767 (37,525)	39,032 (39,043)	37,390 (36,940)	23,710 (23,534)	19,290 (17,168)
Medium--gasoline	19,088	16,640	13,116	11,915	14,860	20,360	24,151	14,075	5,508 (5,490)	1,045 (1,294)	664 (654)	1,660 (1,587)	2,111 (2094)	1,419 (1,438)	2,098 (2,016)
Light--diesel	--	--	--	40	2,734	4,292	5,051	7,326	11,688 (11,672)	17,141 (16,881)	18,523 (18,773)	23,540 (23,359)	26,347 (26,187)	16,647 (16,665)	19,101 (13,898)
gasoline	4,315	4,427	4,010	4,167	5,243	5,363	6,018	3,432	3,115 (2,940)	1,074 (1,098)	524 (509)	n/a	n/a	n/a	n/a
Pick-ups	21,834	21,874	25,707	29,608	39,438	52,017	60,223	59,070	n/a	n/a	n/a	53,796 (53,761)	61,187 (60,056)	38,387 (38,299)	33,491 (32,835)

Note: The 1976-81 data are supposed to be production and sales for the domestic market only. Sales are shown in parenthesis.

Source: Series 1968-75 based on "Agora, Disel em todas as Faixas," Transporte Moderno (Maio, 1976), pp. 64-71. From 1976 on, based on appropriate Production reports in Transporte Moderno, the series are in very close agreement when they overlap, and because the series is more up-to-date than that based on the Anvario Estatistica de Transportes, it has been chosen.

Table 1-2. Change in Relative Shares of Heavy, Semi-heavy and Medium Trucks in New Vehicle Production, 1968-1981

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Jan-Aug 1981
Total production of heavy, semi-heavy, and medium trucks (1,000 vehicles)	37.5	35.9	34.1	34.3	42.5	55.3	64.1	64.2	67.6	82.7	66.8	67.7	72.6	41.9
Percentage of:														
heavy	6.0	7.5	7.0	8.5	7.6	7.2	9.5	10.7	13.0	13.1	11.1	6.1	8.3	8.3
semi-heavy	-	-	8.2	13.7	11.3	10.3	13.2	22.8	26.5	30.4	32.9	33.8	37.3	46.0
medium	94.0	92.5	84.8	77.8	31.1	82.5	77.3	66.5	60.5	56.5	56.0	60.1	54.4	45.7

Note: The Mercedes-Benz 1519/2219 series has been shifted to the category of semi-heavy after discussions with staff of Transporte Moderno.

Source: Based on monthly market surveys of Transporte Moderno. 1981 data are for sales rather than production. This is the only year where the distinction is important.

reflected in reduced fleet growth. This is essentially a mathematical phenomenon which is illustrated in table 1-3. It appears that in the second period automobile fleet growth was even more rapid relative to GDP than in the first. If it continues (which is likely), the slowdown in production will, however, make itself felt on fleet growth in the 1980s. This is one good reason to assume that the $\Delta E_T / \Delta$ GDP ratio will change favorably in the coming decade.

A second factor, less clear, is that it is likely that the road vehicle fleet average age increased. Based on the crude model in table 3, the average age of the automobile almost doubled (from 2.5 years to 4.7 years). Increasing age tends to decrease fuel efficiency. However, even if average lifetimes of cars increases by 10-20 percent (possible with slower economic growth), this trend should also have spent itself by 1985. A similar phenomenon is likely with trucks.

A third factor, least clear of all, is that a change in the freight transport intensiveness of the economy occurred. It seems unlikely that the two factors just discussed would be able to balance all the trends towards improvement. This has led the author to postulate increased transport intensiveness. During this period there was considerable development of rather decentralized heavy industry which led to increased transport of intermediate goods. A good example of this is the petrochemical complex in Bahia which ships much of its output to São Paulo (mostly by truck). Official freight estimates support this thesis, but the author regards them as being of dubious value, (see pages 11 and 12, below). This increase in freight transport intensiveness, a structural problem which could be influenced by broad development choices, has not received serious analysis in Brazil as yet.

It seems very likely that in the 1980s the $\Delta E_T / \Delta$GDP ratio will improve relative to the 1970s. The elimination of two of the unfavorable trends which counterbalanced the favorable ones has been mentioned. In addition to this it is likely that improvement in automobile fuel efficiency and the trend towards heavier trucks should continue. The efficiency gain from the shift to diesel from gasoline trucks has spent itself, but this should be more than compensated for by the introduction of more efficient diesel engines being considered or planned by manufacturers and increasing use of radial tires on trucks and buses. These two factors

Table 1-3. A Simplified Model Relating Automobile Annual Production to Changes in Fleet Size

Rate of growth of new vehicle production (percent)	Year	Approximate new car production	GDP growth rate	Cars retired from fleet	Estimated vehicle fleet	Growth rate of fleet (percent)
--	1962	85,000	--	--	--	--
--	1963	95,000	--	--	--	--
--	1964	105,000	--	--	--	--
--	1965	115,000	--	--	--	--
--	1966	130,000	--	--	--	--
--	1967	140,000	--	--	--	--
--	1968	165,000	--	--	--	--
--	1969	225,000	--	--	--	--
--	1970	310,000	--	--	--	--
--	1971	400,000	--	--	3,125,000	--
17.5	1972	470,000	11.7	85,000	3,510,000	12.3
20	1973	565,000	14.0	95,000	3,980,000	13.4
22	1974	690,000	9.8	105,000	4,565,000	14.7
6	1975	730,000	5.6	115,000	5,180,000	13.5
4	1976	760,000	9.0	130,000	5,810,000	12.2
-4	1977	730,000	4.7	140,000	6,400,000	10.2
5	1978	840,000	6.0	165,000	7,075,000	10.6
5	1979	880,000	6.4	225,000	7,730,000	9.3
5	1980	920,000	8.0	310,000	8,340,000	7.9
4	1981	955,000	6	400,000	8,895,000	6.7
4	1982	995,000	6	470,000	9,420,000	5.9
4	1983	1,035,000	6	565,000	9,890,000	5.0
4	1984	1,075,000	6	690,000	10,275,000	3.9
4	1985	1,120,000	6	730,000	10,665,000	3.8
4	1986	1,165,000	6	760,000	11,070,000	3.8
4	1987	1,210,000	6	730,000	11,550,000	4.3
4	1988	1,260,000	6	840,000	11,970,000	3.6
4	1989	1,310,000	6	880,000	12,400,000	3.6
	1990	1,360,000	6	920,000	12,840,000	3.6

Note: Estimate of fleet size is based on 1977 and assumes an average 10-year lifetime of cars. Thus the fleet in 1978 equals the 1977 fleet plus 1978 production and minus 1968 production. This simplified model gives very close to 1971-1976 estimates cited in reference, however, the figures from 1978 on are intended on to be indicative of tendencies.

Source: Empresa Brasileira de Planejamento de Transportes--GEIPOT, Estudo da Frota Nacional de Veiculos (Brasilia, Ministerio dos Transportes, Junho 20, 1979).

alone could increase average truck fuel efficiency (in terms of ton-kilometers per liter) by 25-40 percent in the early 1990s (see page 9). The intensity with which these favorable trends can establish themselves will depend in part on government policy. Policy in Brazil in the mid- to late 1970s does not give the impression of being well thought out or coherent; but, implicitly at least, it rested on two foundations, to the near exclusion of any other considerations. For passenger transport the basic policy was to increase the price of gasoline and the inconvenience of obtaining it. For freight transport, the policy was to increase subsidized investments in alternative modes to road freight. In 1979 federal investment in road infrastructure was the same as in 1970 (table 1-4), while outlays for railways and shipping more than tripled. By 1981, policy had expanded to include tighter credit conditions for new car purchases, investment in urban surface rail systems, and, in the freight sector, a sharp increase in diesel prices. Two things stand out; one is the use of fuel price as a tool, and the other is the emphasis on modal shift as a strategic objective and a justification for the allocation of investment resources (either by subsidizing or restricting credit). By comparison, another strategic objective, improvement in the efficiency of automobiles, truck, and bus transport, has been relatively ignored, perhaps due to the assumption that it would follow naturally with fuel price increases.

The policy today of stimulating overall efficiency through higher fuel prices appears to be basically sound, though there may be problems with timing and emphasis. The most interesting case to watch will be diesel, the price of which was sharply increased to almost 50 percent over the world price in 1981. This high price level is something of an experiment, especially in developing countries. The trucking industry in Brazil has already shown itself to be relatively responsive to price signals.[1] The range of this response, however, may be constrained by the practical choices facing truckers.

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1. For example, in the rapid shift from gasoline to diesel following the increase in the price of gasoline relative to diesel.

Table 1-4. Approximate Federal Transportation Investments, by Mode, 1970-1979 (billions of 1979 dollars)

Mode	Year					
	1970	1972	1974	1976	1978	1980
Air	0.1	0.1	0.3	0.3	0.1	0.2
Pipelines	0.1	0.3	0.6	0.2	0.2	0.1
Navigation	0.2	0.4	0.5	0.7	0.7	0.7
Railways	0.4	0.8	1.1	1.9	1.6	1.5
Highways (infrastructure)	1.3	1.5	2.3	1.6	1.6	1.2
Highways (vehicle acquisition)	2.4	3.0	2.8	3.5	4.1	4.2
Total	4.5	6.1	7.6	8.2	8.3	7.9

Source: Cloraldino Soares Severo, "O Problema Energetico e os Transportes--Experiencia Brasiliera," paper presented at the Seminario sobre el Impacto del Costo de la Energia en el Sector Transporte (Bogota, Colombia, December 1-3, 1980).

It is hard to shift to a more efficient engine if it is not on the market. It is hard to shift to a larger truck or reduce empty backhauls if the infrastructure does not exist to make the choice commercially viable. A more coherent policy of energy conservation than exists today would support the fuel price policy by actively addressing these constraints. Automotive gasoline presents a comparable situation. Such a policy to reinforce fuel price-induced efficiency improvement within the road transport sector has been almost completely overshadowed by the emphasis on modal shift.

"Modal shift" can mean different things in the passenger and freight transport sectors. In passenger transport it can legitimately mean a significant slowdown in the rate of expansion of the relatively small share of passenger trips in cars (which in energy terms dominate passenger transport), even though the share of trips continues to increase. This is because, in a country like Brazil which has until recently experienced a

rapid shift toward private cars which was widely expected to continue at a fairly rapid rate, stabilization or a slow rate of increase represents a major shift in future modal shares. In freight transport it unambiguously means decreasing the existing large, relatively stable share of freight carried by trucks. Many transport planners see little hope over the 1980s for a significant shift in freight transport despite large investments and the higher price of diesel. The author shares this view for both technical and institutional reasons to be discussed later. The history of the modal shift strategy for freight has not been particularly encouraging until now.

On the side of passenger transport the situation may be quite different. The constraints on credit for automobile purchase appear to be an effective tool. In addition to this some market saturation may be occurring. A slowdown in the growth of car ownership relative to GDP appears to be almost inevitable. Whether car owners can be induced to use their vehicles less is more questionable, although the increase of fuel prices and the erosion of middle class incomes have had a visible effect on the amount of urban driving. An important factor in the longer term for the size of the fleet, and to a lesser extent, the intensity of automobile use, is likely to be the quality of urban transport. However, successful planning will concentrate on upgrading the quality of collective transport for its primary users today, and will do so in a context of overall city planning, rather than getting motorists out of their cars. In this work the innovative experience with collective transport in one city, Curitiba, will be discussed in some detail. Curitiba is important for the principles that have been consistently applied and its emphasis on relatively low-cost modifications to the bus system. This experience, as well as the general reaction to the new high diesel prices and the increasing evidence of the impact that improved maintenance procedures can have on fuel consumption, are likely to be the things of greatest interest in Brazil's transport sector to policy planners in other developing countries.

Chapter 2

INTER-URBAN FREIGHT TRANSPORT

Any analysis of energy demand and efficiency of use in freight transport in Brazil must begin with the fact that freight transport is dominated by trucks. Official statistics show a fairly constant 70 percent of intercity ton-kilometers being carried by trucks over the period 1968-1979 (varying between 72 and 67 percent by beginning and ending at 70 percent as shown in table 2-1). These official statistics are almost certainly wrong both in terms of the relative magnitude of truck transport and its change over time. Nevertheless, trucks are the dominant form of freight transport and overwhelmingly so if we exlude iron ore which alone was responsible for two-thirds of the ton-kilometers hauled on railways in the late 1970s [2].

As a consequence of this dominance, the weight of energy policy discussion formulation and sometimes even action regarding freight transport has concentrated on two themes: a shift of freight transport from trucks to more efficient modes (railway and waterway); and increasing the efficiency of truck freight itself.

There have, of course, been other themes. First among these is substitution for petroleum derivatives by other energy forms--alcohol and vegetable oils in trucks, and electricity in railways. Neither of these is strictly speaking an energy conservation measure (though railway electrification may involve some efficiency increase, even when generated from thermal power plants). Neither substitution for diesel in trucks nor railway electrification has made any headway.

Another possible theme, increasing the efficiency of fuel use in the rail and waterway modes, has received little attention in the literature,

Table 2-1. Change in Mode of Intercity Freight Transport as Officially Estimated by GEIPOT

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Road freight	102.4	112.9	124.5	137.3	152.1	168.0	185.5	204.8	226.2	249.7	275.7	304.5
(percent increase over previous year)	-	10.3	10.3	10.3	10.8	10.5	10.4	10.4	10.5	10.4	10.4	10.5
Railroad	21.5	25.0	30.3	31.9	33.3	42.5	54.7	58.9	63.3	60.7	64.1	73.8
(percent increase over previous year)	-	16.3	21.2	5.3	4.4	27.6	28.7	7.7	7.5	-4.1	5.6	15.1
Coastal shipping	21.2	22.7	21.6	24.0	21.8	24.0	29.4	31.7	32.6	35.5	39.5	44.2
(percent increase over previous year)	-	7.1	-4.8	11.1	-9.2	10.0	22.5	7.8	2.8	8.9	11.3	11.9
Air freight	0.19	0.19	0.20	0.24	0.31	0.38	0.45	0.52	0.66	0.69	0.79	0.92
(percent increase over previous year)	-	0	5.3	20.0	29.2	22.6	18.4	15.6	26.9	4.6	14.5	16.5
Pipeline	0.97	1.95	2.33	2.79	3.80	5.02	5.48	6.30	6.98	8.38	10.96	11.21
(percent increase over previous year)	-	101.0	19.5	19.7	36.2	32.1	9.2	15.0	10.8	20.1	30.8	2.3
Total	146.3	162.7	178.9	196.2	211.3	239.9	275.5	302.2	329.7	355.0	391.1	434.6
(percent increase over previous year)	-	11.2	10.0	9.7	7.7	13.5	14.8	9.7	9.1	7.7	10.2	11.1
Road freight	70.0	69.4	69.6	70.0	72.0	70.0	67.3	67.8	68.6	70.3	70.5	70.0
Railroad	14.7	15.3	16.9	16.2	15.8	17.7	19.8	19.5	19.2	17.1	16.4	17.0
Coastal shipping	14.5	14.0	12.1	12.3	10.3	10.0	10.7	10.5	9.9	10.0	10.1	10.2
Air freight	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Pipeline	0.7	1.2	1.3	1.4	1.8	2.1	2.0	2.1	2.1	2.4	2.8	2.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Empresa Brasileira de Planejamento de Transportes--GEIPOT, Anvarao Estatistico dos Transportes--1980 (Brasilia, Ministerio dos Transportes, Dezembro 1980).

though there appear to have been some savings as a result of a tightening up of operating procedures in general in the railways.

Finally, there is the matter of reducing the transport intensiveness of the economy. This theme is touched on fairly often, but the author has yet to see a serious work on the subject in Brazil. As table 2-2 (based on official statistics) shows, Brazil is a transport-intensive economy, and this intensiveness actually increased during the 1970s,[2] although the coefficient has probably been inflated by the official estimates of ton-kilometers. Only the United States and, strangely enough, India, come close among the countries listed. The size of the country does not appear to be such an important factor as might be thought at first. Average rail hauls are quite short, about 450 kilometers (380 kilometers if we exclude iron ore, as shown in table 2-3), and the best available evidence on trucking suggests that average intercity hauls are 430 kilometers [3].[3] In the United States, by comparison, the average rail haul exceeds 850 kilometers. The emphasis on mineral and export agricultural production probably has some effect on the coefficient. However, the most common criticism is the relatively centralized industrial structure of the country. At present it is virtually impossible to quantify the problem and, with limited time and resources at hand, the author has chosen not to attempt it or even to theorize how changing industrial geography and economic structure have influenced transport intensiveness in the past and may influence it in the future. Nevertheless, the problem is significant and, as discussed already in the introduction, may have been an important factor in the lack of overall efficiency improvement in the transport system during the 1970s.

We are thus left by and large with the two principal themes cited at the outset--modal shift and increased fuel efficiency in trucking. What has happened, what might happen, and what are the problems which have emerged?

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2. If we believe the official statistics, the transport intensiveness has continued to increase since 1973 and has reached 5.6.

3. It is curious to note that the average intercity truck haul appears to be longer than the average railway haul, if we exclude iron ore, where the two modes do not compete.

Table 2-2. Transport Intensiveness in Less Developed Countries (ton-km per $ of GDP)

	Taiwan	Korea	India	Pakistan	Morocco	Turkey	Brazil	France	Germany	Italy	U.K.	USA
1950	1.0	n.a	2.2	n.a	n.a	n.a	2.5	n.a	1.8	n.a	n.a	n.a
1955	1.3	.8	2.4	n.a	.9	1.1	3.3	n.a	1.5	1.1	n.a	4.6
1960	1.2	1.2	2.6	1.9	.9	1.1	3.4	1.2	1.3	1.1	1.1	4.2
1965	.9	1.3	3.7	1.8	.9	1.4	4.3	1.3	1.2	1.0	1.2	4.0
1970	.8	1.8	3.5	1.6	1.0	1.8	4.8	1.3	1.1	1.0	1.2	4.0
1971	.7	2.0	3.6	1.6	1.0	1.7	4.8	1.2	1.1	1.0	1.2	3.9
1972	.9	1.6	3.7	1.7	1.0	1.6	4.6	1.2	1.1	1.0	1.2	3.9
1973	.7	1.6	3.4	1.7	1.0	1.6	4.6	1.3	1.1	1.0	1.2	3.9
1974	.8	1.6	4.0	1.7	1.1	1.5	n.a	1.3	1.1	n.a	1.1	3.9
1975	n.a	n.a	n.a	1.8	n.a		n.a		1.0	n.a	1.1	3.8

Source: Source book of Freight Statistics; by mode, by country, Transportation Department, International Bank for Reconstruction and Development.

Table 2-3. Major Cargoes on the Federal Railway System (RFFSA)--Changes in Ton-Kilometer and Average Distances of Haul, 1973-1979

Product	Freight hauls (10^6-ton-km)			Average distance (km)		
	1973	1977	1979	1973	1977	1979
Iron ore	4,224	11,403	11,066	511	557	632
Cement	1,365	1,774	2,188	560	352	633
Petroleum derivatives	1,505	2,050	3,017	663	498	478
Iron and steel	584	1,330	1,992	510	261	324
Sugar	397	367	358	192	221	368
Fertilizer	450	663	1,024	339	464	436
Limestone	371	642	865	298	310	279
Wheat	488	887	1,137	457	382	439
Feed	n.a.	777	905	17	389	372
Soybean	n.a.	895	664	n.a.	640	635
Everything except iron ore	9,773	13,720	16,574	363	356	383
Total	13,997	25,123	27,640	398	426	455

Note: n.a. signifies not available.

Source: Empresa Brasiliera de Planejamiento--GEIPOT, Anuario Estatistico dos Transportes (Brasilia, Ministerio dos Transportes) for years 1975, 1978, 1980.

Improving the Efficiency of Truck Transport

In comparison with modal shift as a means of reducing energy use, increasing the efficiency of energy use within the truck transport sector has received relatively little official attention or priority, despite the fact that savings on the order of 50 percent per ton-kilometer at the margin could probably be achieved over a 15-20 year period (see table 2-4). Of the most important ways to improve the efficiency of the truck transport system as it existed in 1974, only one (a shift of medium and light trucks from gasoline to diesel) was encouraged by government policy during the 1974-1979 period. This shift, provoked by a sharp increase in the price of gasoline relative to diesel, was in fact only a secondary objective of the price policy.

Table 2-4. Fuel Consumption per Ton-Kilometer of Loaded Trucks of Increasing Size

Truck type	Useful load (1000 kg)	Ton-kilometers per liters of diesel
Mercedes-Benz 1113	7.3	26
Mercedes-Benz 1113 with third axle	12.0	38
Mercedes-Benz 1513 with third axle	15.0	45
Saab Scania L111 with 3-wheel trailer	32.0	58
Saab Scania T112 with two trailers	60.0	78

Source: Fuel consumption for Mercedes-Benz and Scania L111 from "Custo Operacional de 78 Veiculos," Transporte Moderno (Maio 1981), pp. 30-47, and assumed normal intercity haul conditions at full load. Useful load from Transporte Moderno staff. Figures for Saab Scania T112 E from "O treminhao no transporte de cana," Transporte Moderno (Agosto 1981), pp. 20-22. This is for cane hauling on mixed clay and asphalt roads at 35 km/hr. These conditions are not typical of intercity freight.

The Brazilian system of intercity road freight which existed in 1974 offered very significant opportunities for increased energy efficiency. Seven years later, these opportunities still exist, by and large. What this means is that rather little has happened in the interim.

This relative paralysis was a result of several factors:

a. the reluctance of the government to pursue a coherent fuel price policy to stimulate efficiency;

b. institutional difficulties in the road transport sector itself which, among other things, inhibited certain critical investments, standardization of equipment, and broad acceptance of innovative ideas;

c. in interaction with (b) delays by some important manufacturers supplying the sector marketing new, more efficient equipment adapted to the conditions of the country;

d. government regulations, especially for gross vehicle size and weight, which effectively made heavy trucks uneconomic unless they were operated in violation of the limits on weight per axle and which in fact resulted in frequent violations;

e. an otherwise laissez-faire policy by the government, which took the form of not only no action to identify or resolve impasses caused by (a-d) above, but poor enforcement of what few rules exist, and poor collection of data necessary for policy making.

Starting in 1980 this situation has begun to change, although it is still too early to quantify the impact, or indeed, to see how vigorously measures will be pursued to realize the potential improvement in the energy efficiency of the system. An important first step taken was to raise the price of diesel. As can be seen in the figures on fuel prices, this policy was instituted with a vengeance, and after years of cushioning consumers through subsidies (between 1972/73 and 1978/79 the real price of diesel rose only 33 percent), diesel is now about 50 percent above the world market price.

The Brazilian trucking industry is unregulated and very competitive. Within the constraints that they face, individual truckers and firms will seek to optimize their total costs around the new higher fuel cost. Possible measures are likely to be a substitution of radial for conventional tires, improved maintenance, that is, setting of diesel injectors to the more efficient (but less powerful) point recommended by manufacturers, and retrofits such as turbocharging (airfoils, however, have limited application). At the moment radial tire sales for trucks are expanding rapidly (75 percent per annum), although they still account for only a very small part of the market (about 5 percent in 1981) [4]. Tests by consumers in Brazil suggest a fuel saving of 6-10 percent [5]. Three technical measures (by no means a complete list) for which it was not possible to estimate the impact on overall fuel consumption are discussed schematically in appendix C.

The price elasticity of demand is limited, however, by features of the industry landscape over which individual truckers have no control but which influence their choices. Three important cases in which this can be seen are the efficiency of available engines, empty backhauls, and a shift to larger more fuel-efficient trucks.

Although the author does not have systematic data for all manufacturers and truck sizes, it appears that the efficiency of the diesel

engines being mounted in medium and semi-heavy trucks (which predominate) is not very high. The basic Mercedes Benz engine used has a consumption of 190-200 grams of fuel per horsepower-hour (g/hp-hr), while 135-145 g/hp-hr is the norm in the United States. Mercedes Benz is the largest truck manufacturer in Brazil. The fuel consumption of comparable trucks made by General Motors and Ford is comparable. It was only in 1981 that Mercedes Benz announced its plans to produce a more efficient engine in Brazil in the next several years. This delay in phasing out an obsolete engine highlights the weakness of past government policy in the area of energy conservation.

Another major source of potential energy saving is in switching to heavier trucks. The trucking industry has steadily moved toward larger, more fuel-efficient trucks as shown in table 1-2. The proportion of new trucks produced in the medium category (7-12 tons of cargo) fell from more than 80 percent in 1973 to 45 percent in 1981. The overwhelming beneficiary of this shift has been the semi-heavy category, which rose from 10 percent in 1973 to 40 percent in 1981. Heavy trucks (32 tons or more), after showing signs of growth in the mid-1970s, fell back to a market share very close to that in 1971-1973.

The behavior of the past few years shows a tendency towards incremental changes, that is, upgrading truck capacity by 25-30 percent. This sort of change is relatively straightforward for a firm since the truck size fits comfortably into existing freight patterns. In impact, it is not unlike shifting to diesel from gasoline or to radial tires, and given sometime the market can respond. Heavy trucks, however, present a different problem. For many types of freight, going to heavy trucks will represent a qualitative change in patterns. The most important change is the need for more transshipment between intercity trucks and trucks for distribution. There is little infrastructure for this in Brazil, which has a tradition of door-to-door shipment in a single vehicle. Terminal facilities are very limited and there is little provision for efficient handling of freight. For example, there are no standards for pallets. Another problem in going to large trucks is the relatively large up-front capital investment required. Given the limited resources of most truckers, and the high insecurity of the business, this presents a formidable

obstacle, despite the fact that a heavy truck in proper condition has lower total costs per ton-kilometer.

These structural problems of the trucking industry are the probable explanation for the stagnation of the market share of heavy trucks in Brazil. If Brazil is to take full advantage of the potential of this option, there will have to be a coherent public policy. The problems associated with heavy trucks are accentuated even further with "truck trains," powerful multiple trailer units in the 60-100 ton capacity range. These appear to have very high fuel efficiencies (actually approaching the average of Brazilian railways). Rather common in parts of Africa, as well as in some developed countries, they are still illegal in Brazil. Limited tests are being carried out to observe the impact of truck trains on intercity traffic flows. Widespread use of these units is likely to require some regulations on mode of use[4] as well as investments to upgrade key intercity routes. This will probably require policy choices running counter to the current investment strategy, which emphasizes modal shift. This can be seen in table 1-4.

Such a policy appears to be unlikely during the current administration. Indeed, in terms of investment priority even the far more nominal investments for freight terminals rank low. As table 2-5 shows, the government is preparing to invest twice as much in policing axle weights as in rationalizing the freight system. This is unfortunate, because terminals are likely to be a crucial element in improving load factors in trucking, another frequently mentioned potential source of fuel savings. The existence of central terminals should allow a greater integration of What is currently a rather fragmented market.

Modal Shift

Shifting freight from truck to more efficient modes has been the primary policy of the Brazilian government since 1973/74. This strategy has not lived up to expectations. Table 2-6 is a projection of goals for

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4. This may seem trivial, except that the truck sector is anarchic. There is not, for example, a minimum set of enforced standards and training for something as obvious as transport of toxic chemicals.

Table 2-5. Federal Program of Alternative Transport--
Planned Investments for 1980/81

	Millions of cruzeiros in January 1980	Percent
I. Urban Transport	91,164	68.1
Urban Railway	53,636	40.1
Rio de Janeiro	21,832	
Sao Paulo	7,604	
Porto Alegre	7,500	
Belo Horizonte	7,500	
Salvador	5,200	
Recife	3,000	
Fortaleza	1,000	
Urban Buses	23,231	17.4
Corridors	8,450	
Traffic control systems	3,000	
Road infrastructure improvement	3,500	
Bus fleet	8,281	
Trolleybus	10,000	7.5
Urban waterway	4,297	7.5
II. Freight transport	41,856	3.2
Truck freight	3,774	31.3
Freight terminals	1,215	
Control of axle weight	2,559	
Railway	19,500	14.6
Completion of line to Paranagua	19,500	
Waterway (incl. roll-on/roll-off)	3,203	
Coal transport program	15,379	11.5
Port development	6,643	
Railway development	8,736	
III. Studies and planning	716	0.5

Source: Regis Ribeiro Guimeraes (GEIPOT), "A crise energetica e a busca de novas saidas," 1° Seminairio TM sobre Politica e Legislacao de Transporte, Editora TM Ltda. (Sao Paulo, Novembro 17-19, 1981).

Table 2-6. Projections for Road, Rail, and Waterway Freight Traffic for 1974, 1980 and Actual

Mode	Freight hauled					
	Estimated in 1974		Projected for 1980		"Actual" (estimated) in 1979	
	billion ton/km	%	billion ton/km	%	billion ton/km	%
Road freight	184.4	71.7%	246	54.0%	304.5	72.1%
Rail freight	47.6	18.5%	144	32.0%	73.8	17.5%
Waterway	25.2	9.8%	64	14.0%	44.2	10.4%
Total	257.2		454		422.5	

Source: The estimates for 1974 and the 1980 projections are from Cloraldino Soares Severo, "Cada Modalidade no seu Devido Lugar," Transporte moderno (julho 1975), pp. 91-94. They were made by the then-president of the Empresa Brasiliera de Planejamiento de Transportes (GEIPOT), the primary planning body in the Ministry of Transport. Estimates for 1979 are from Empresa Brasiliera de Planejamiento de io dos Transportes--GEIPOT, Anvario Estatistico dos Transportes--1980 (Brasilia, Ministerio dos Transportes, Dezembro 1980). Totals exclude air freight and pipelines, both relatively minor. Projections for total based on a growth in GNP from U.S. $80 billion in 1975 to U.S. $140 billion (1975 dollars) or 11.8% per year. The 1974 estimates were later revised by Empresa Brasiliera de Planejamiento de Transportes--GEIPOT, Plano Nacional de Transportes--Diagnostico, vol. IV, Sistema Rodoviario (Brasilia, Ministerio dos Transportes, Dezembro 1978, to the following:

Road freight	185.5	billion	t-km	- 68.8%
Rail freight	54.7	"	"	20.3%
Waterway	29.4	"	"	10.9%
Total	296.6	"	"	

These revised estimates for 1974 are essentially consistent with those published in Anvario Estatistico dos Transportes--1980 for 1979. This makes the projections slightly more disastrous.

modal shift estimated in 1975 by the then head of the transport policy agency. Truck freight was to fall from 72 percent in 1974 to 54 percent in 1980. Official estimates for 1979 (table 2-1) show a slight increase in truck freight as a percentage of the total. If these estimates are to be believed, then the policy has been a complete, and rather expensive, failure.

The situation may in fact not be as bad as it seems because of deficiencies in the estimates of the quantity of inter-urban freight transport.

Official estimates give the impression that Brazilian freight transport is very heavily dominated by truck transport, and have been the basis for the view that the Brazilian transport sector suffers a fundamental distortion in modality. In this light it may come as a surprise that Brazil's railways, pipelines and waterways carry as much freight as West European economies with three times the GDP. Brazilian railways carried more freight ton-kilometers than those of any member country of the Organization for Economic Cooperation and Development (OECD) except the United States and Canada, and, urlike most rail systems, the volume is growing.

Professionals in the field in Brazil recognize that the basis for estimates of truck freight is very precarious. A feeling for their arbitrariness can be seen in table 2-1, which shows exceptionally stable growth in intercity truck ton-kilometers (except in 1972, growth was estimated to lie between 10.3 and 10.5 percent in all years) from 1969 1979 despite threefold variations in annual economic growth. Unfortunately, despite this recognition, little has been done about it, and literature on Brazilian transport repeatedly cite these highly suspect figures as though they represented reality.

The author's impression is that the amount of intercity truck freight is significantly less than the official estimates. The official estimates suggest that Brazil's total freight volume is as large as that of France and Germany combined (which have six times the GDP), yet on the other hand, percentage contribution to GDP of the transport sector is characteristic of international standards (5-6 percent) [6].

The implied extraordinary transport intensiveness of the volume estimates is a direct result of the high truck transport estimates. These estimates are belied by other official Brazilian work. The Operational Plan for Transport estimated that 163 billion ton-kilometers were hauled on the most important 85 percent of the roads outside of the sparsely developed northern (Amazonian) region, yet the official total truck freight modal estimate for that year is 250 billion ton-kilometers [3].

The author's preliminary work suggests that even the volume implied by this reduced estimate may be too high. This issue is very complicated and

its resolution is clearly beyond the limited resources of the work done here, but it is important to highlight the problem which has often been swept under the rug. If the author's assessment is correct, its main implication is a somewhat reduced emphasis on modal shift as a strategy.

Although it is not possible to be quantitative, it is nevertheless clear that the policy of modal shift has achieved little. This appears to be due in part to the poor planning of investments. For example, the most important investment in railway infrastructure in the 1970s was the "Ferrovia de Aco." This railway essentially adds to the capacity of the Central Line of the Federal Railway System which principally handles by iron ore shipments. It is now apparent that the capacity developed at great cost, in addition to what might have been added by upgrading the Central Line itself (one of the lines in best condition in Brazil), will not be utilized in this decade, nor has there been an indication that this new line will contribute significantly to a modal shift in the region. Another example is the surge in locomotive and freight car purchases in the mid-1970s, which was intended as a prelude to an even higher level of purchases later. Manufacturers invested in new capacity, which was promptly made idle by the government's belated realization that the poor utilization of existing rolling stock, not the physical quantity of stock, was the key problem.

Various attempts at intermodal road/rail transport have not fared well. There have been three attempts to establish a piggy-back system (where the trailer is put on a flat-bed car). All have been uneconomic due to scheduling problems, bureaucracy, low train speed, delays in loading and unloading, and pilfering [7]. Auto-train (where the whole truck is carried) was also found to be economically unattractive. Some other forms of road/rail integration (for example, transporting new cars) have had modest success, while roll-on/roll-off road/ship integration is beginning to look dubious despite ambitious plans.

The government even tried to decree modal shift on January 17, 1977. All state enterprises, public bodies, and autonomous state organizations were to transport their freight by train or boat. Since the state controls almost two-thirds of the economy, this could have been significant. However, outside of steel products and perhaps oil derivatives, this act appears to have had little impact. Iron and steel products in fact appear

to have been the major success story in modal shift (see for example table 2-3) due to a coordinated effort.

There is every indication that even with good planning a significant modal shift will occur slowly. Major new railway lines require 10-15 years to complete, and the railways have in general not been able to increase the quality of their service adequately. There are also fundamental factors militating against a rapid increase in railway traffic. First, fluxes on most intercity routes are not high, making it difficult to justify the large investment costs for railways. Second, average trip lengths are not long; about 450 kilometers for railways (about half the U.S. average) (see table 7), and about 430 kilometers for trucks [3].

This prognosis suggests that from the point of view of energy conservation, the most cost-effective investments in general over the next few years will be in increasing the efficiency of the road transport sector itself, rather than in modal shift. This conclusion is likely to be rather unpalatable to many. This does not mean, however, that the railway and shipping sectors should be returned to their pre-1973 status, but that planning should be predicated on a slower shift and more realistic appraisals of how it can be achieved. This will mean attention to management as well as investment. It is possible that some developments implicit in a rationalization of truck transport will in fact help ease the way for a later modal shift. Terminals and the more complete integration of heavy trucks in the trucking system can be viewed as a step toward the kind of specialization, concentration of traffic flow, and integration needed for an efficient rail system. This intermediate step is somewhat analogous to some promising developments in urban passenger transportation initially using bus rather than rail systems.

Chapter 3

URBAN PASSENGER TRANSPORT

Prior to 1973/74 urban passenger transport in Brazil was marked by a steady shift towards the private automobile and a steady deterioration in the quality of collective transport. From 1973/74 until 1979/80 the shift toward private automobiles continued, albeit at a slower rate; and with a modest trend toward a more efficient car fleet. The quality and efficiency of collective transport did not improve, with several specific exceptions. In general policy towards collective transport remained confused and ineffective. The slowdown in the shift toward the use of personal cars appears to have had little to do with any increase in the attractiveness of collective relative to personal transport. This modest change must be ascribed to such factors as a general slowdown in economic growth, changes in financing, a slowdown in the rate at which the real cost of owning and operating a car declined, and perhaps some saturation of the Brazilian market capable of affording a car.

Any new phase appears to have begun in 1980/81. The clearest change is in the costs of car ownership, which have actually begun to increase in real terms and are likely to remain higher than in the 1974-1980 period. New car production for the Brazilian market is likely to increase more slowly than before, or even stabilize for a while, once the immediate effects of the deep recession in 1981 have passed. Increased emphasis on exports, if nothing else, may force manufacturers to be more aggressive in improving fuel efficiency, which has received minimal attention until now.

In addition, rail mass transit will be substantially improved by investments now being made in "surface pre-metro" systems in seven metropolitan regions as well as the imminent completion of the important east-west line of the São Paulo metro, probably the only metro line which should have been built but which unaccountably was given lower priority than the north-south line in São Paulo and the Rio metro.

A very big question mark, however, still hangs over bus transport, which is the dominant mode of urban passenger transport. There is still no clear consistent government policy designed to overcome the many problems afflicting bus transport, despite some valuable innovative experience gained in 1974-1980 (principally in Curitiba). An institutional change made in 1981 may have important but as yet unpredictable consequences. The level of bus tariffs in each city was, incredibly enough, until recently set by a federal institution. This mechanism tended to divert pressure to keep costs down. Now tariffs are to be set by the municipalities themselves.

This simple measure is generating far more resistance to fare increases, since mayors are more politically exposed. It is also possible that this will lead to more concerted pressure to improve the overall efficiency of urban bus systems, for which there are considerable options. An increase in efficiency must also be an important part of policies responsive to the needs of the urban poor and which recognize the social and political tensions that may arise from their neglect.

In reviewing the changes in Brazil during the period 1973/74 to 1979/80, and the perspective for the next few years, it is useful to begin by reviewing the broad strategies available to reduce fuel use for passenger transport. These are roughly parallel to those cited earlier for intercity freight: improvement in fuel efficiency of a given mode, "modal shift," electrification, and reduction in the amount of travel necessary.

Improved Efficiency of a Given Mode

This approach has received relatively little explicit emphasis in Brazil until now, whether for buses or, more importantly, for cars. This is in sharp contrast to the United States, where explicit measures to increase automotive efficiency constitute the key response to reduce passenger transport fuel use.

Private Transport

Fuel efficient passenger transport. This does not mean that the government has pursued no policies to increase fuel efficiency. The policy of high gasoline prices which has been maintained since 1973/74 should be

expected to have had some effect on the market for more fuel efficient cars, even if that was not its primary objective. It can be argued that this is in fact the most appropriate way to stimulate the creation of a more fuel efficient vehicle fleet.

Unfortunately, and this is indicative of the lack of serious attention to this option, the author has been unable to find any analysis of how the average efficiency of new cars sold in Brazil has changed, or indeed what the average efficiency is. A simplified attempt at such an analysis for the years 1973-1978 was attempted for this report and is described in appendix B. The results suggest that a modest improvement did take place. In 1978 the average new car sold was about 8-9 percent more efficient than in 1973. Bearing in mind the limits of the calculation, however, several questions present themselves. If we exclude Fiat, which entered the Brazilian market with a small car planned before the crisis (and is responsible for almost two-thirds of the total calculated new fleet improvement), the remaining small improvement is due to customers switching between existing makes. If the analysis were extended to 1980/81 there would be little difference in the diagnosis (although Volkswagen did introduce the modestly more efficient Golf). The impression one gets is that manufacturers have been less than aggressive about introducing new, more efficient cars. The apparent stagnation raises many questions, given the clear scope for improvement (Brazilian cars are small and average only about 10 km/liter, or less), all the activity elsewhere in the world, and the well-known fact that a given make of car is less efficient than its European or American cognate.

Gasoline quality. An important point regarding the efficiency of cars is the low quality and octane of Brazilian gasoline, characteristics which show no sign of changing. A direct consequence of this is that the compression ratio of motors must be lower (it is around 7 in Brazil while it is 9-10 in the developed world) and significantly less efficient (10-15 percent) than they might otherwise be. The ramifications in terms of engine development and efficiency could go beyond this. Low quality gasoline is also a part of government policy in Brazil as expensive gasoline, but produces the opposite results. This, combined with the lack of any pressure on manufacturers to introduce more efficient cars into the safely closed national market, clearly indicate the lack of a coherent

strategy to improve vehicle efficiency. Although the simple economic solution of raising gasoline prices appears to have had a salutary impact, this trend will not continue without government policy changes and action to redefine the market environment. This is unfortunate because they will probably not happen. A major reason for pessimism on this point is the existence of the National Alcohol Program, reinforced for a few years by the impact of the changed price differential between gasoline and diesel since 1973.

Fuel alcohol. For national fuel alcohol production to appear justifiable economically it is essential that ethanol be assigned a significantly higher efficiency of use than gasoline. For Phase II of the alcohol program (cars running on pure hydrated ethanol), this essentially means that alcohol cars must be more efficient (in energy, not volume, terms) than gasoline cars. A concerted program to stimulate a more efficient new car fleet as a whole would inevitably diminish (or perhaps even eliminate) the claimed superior efficiency of alcohol, damaging the credibility of this priority program. For example, at a minimum, much of the advantage of higher octane would be lost. On the positive side, the alcohol program has at least stimulated the introduction of more fuel-efficient vehicles (in energy terms) for one part of the automobile market.

Gasoline diesel use. This constraint on government thinking is exacerbated by developments in demand for gasoline. The high price of gasoline relative to diesel since 1973/74 stimulated a major but unmeasurable shift of medium and light road freight from gasoline to diesel (see table 1-1). The shift away from the use of gasoline for freight plus the increasing level of alcohol production and the slowdown in new car production relative to GNP (and even more relative to expectations of a few years ago) have all combined to create a gasoline glut, as well as an alcohol glut,[5] on the internal market. In this circumstance efforts to stimulate improved efficiency beyond what manufacturers themselves have planned are unlikely to be pushed very hard, despite a little rhetoric in the Brazilian Energy Model. Whether the auto manufacturers' slow

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5. With no fanfare, the 10.5 billion liter goal has been changed to 1987, and no new alcohol projects are to be started.

historical rate of introduction of more efficient models will persist, the author cannot judge.

Radial tires. One favorable trend--the increasing use of radial tires--is likely to continue. This factor, combined with a desultory rate of introduction of fuel-efficient models, should ensure a slow, steady rate of improvement (perhaps 1-2 percent per year). It should not be forgotten that alcohol cars are in principle about 15-20 percent more efficient in energy terms than gasoline cars, even though this advantage (as we have noted) is somewhat arbitrary. If production of alcohol cars can stabilize at 30 percent of the new car market, this can have a significant additional impact. Unfortunately, the alcohol car market is now extremely uncertain. As can be seen in table 3-1, sales had collapsed in mid-1982 relative to late 1980,[6] dropping from 50 percent to 10 percent of new car sales.

Road improvements. The government has been most active in promoting increased fuel efficiency through improvements to the urban road system to reduce congestion. The author has not been able to study the impact of this measure, which can in some cases have the opposite effect of stimulating private car use.

Public Passenger Transport

The other major consumer of fuel for urban passenger transport is the bus fleet, which is estimated to be responsible for about 8 percent of national diesel consumption (see table A-2). This is an order of magnitude less than the fuel consumption by private automobiles (most of which is in urban areas) and, in terms of potential impact, efficiency improvements here will necessarily be less important. However, from the perspective of operating costs, fuel is very important, amounting to 25-30 percent of the total [8]. Other factors combine with this to make improved efficiency a matter of very high priority: the likely persistence of a government policy to maintain high diesel prices without any subsidy for urban buses and mounting pressure to keep bus fares low.

Until now it appears that very little improvement in fuel efficiency has been achieved, but opportunities exist, particularly from improved

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6. This was the subject of ongoing political debate [8].

Table 3-1. Production of Alcohol Cars

	Production of new cars to use alcohol (thousand)	Cars adapted to use alcohol (thousand)	Accumulated total of alcohol cars (thousand)	Consumption of hydrated alcohol (1,000 m^3)	Average consumption per car (liters/month)
Accumulated in					
1979	4.6	5.0	9.6	--	--
1980					
Jan	0.6	0.8	11.1	2.9	301
Feb	1.9	0.9	13.8	3.8	346
Mar	3.6	1.2	18.7	6.8	493
Apr	3.1	1.6	23.3	15.3	820
May	9.9	2.1	35.3	19.5	836
Jun	18.8	1.0	55.2	18.3	517
Jul	12.2	1.4	68.8	29.5	534
Aug	22.0	2.5	93.3	40.0	581
Sep	30.9	2.8	127.0	57.7	618
Oct	43.4	6.4	176.8	69.2	545
Nov	55.8	4.9	237.6	75.1	425
Dec	51.7	3.3	292.6	91.1	383
Total 1980	258.6	33.9	292.6	429.2	533
1981					
Jan	39.6	2.8	335.0	107.8	368
Feb	33.3	3.0	371.3	96.3	287
Mar	18.3	2.9	392.5	112.6	303
Apr	13.1	2.3	407.9	120.3	306
May	12.0	1.2	421.1	119.7	293
Jun	5.5	0.6	427.1	116.7	277
Jul					
Aug					
Sep					
Oct					

Note: Average consumption per car calculated using total alcohol car fleet of previous month.

Source: To June 1981, Conjuntura Economica, September 1981.

engines. As discussed in the chapter on freight transport, Mercedes Benz will begin producing new, more efficient engines in several years. With 90 percent of the market, Mercedes is overwhelmingly the major producer of engines used in buses.

It also appears that a major increase in fuel efficiency as well as reduction in overall costs can be obtained with improved maintenance. The impression is necessarily imprecise, but there are indicators. In São Paulo a bus company with a strong maintenance program consumes 40 percent less diesel per vehicle than another company with more typical habits operating under similar conditions [9].[7] The whole subject of maintenance is beginning to interest the road transport sector and it is a favorite topic for professional seminars [10]. It is beginning to look as though maintenance has been underrated in policy discussions as a practical way of influencing energy consumption. Poor maintenance is a pervasive problem in developing countries. It is possible that the increase in attention which the problem is receiving in Brazil would be of interest to other countries, particularly in Latin America.

Improvements in tires, specifically a shift to radials, are another significant area for increased efficiency. Tests by a bus company in São Paulo indicate a 15 percent improvement for urban buses, which seems very high [11]. As with trucks, use of radials is still very limited.

Finally, improvements in traffic flow and system rationalization can save fuel use. In Curitiba, where this process has gone further than anywhere else, savings have been observed, though the author was unable to obtain quantitative information. This experience of Curitiba is still somewhat isolated. The effect of congestion on bus fuel use is obvious enough--each bus requires more fuel per kilometer--and because they are slower, more buses are required to move the same number of people in the same time. Over and above this problem, but contributing to it, is the observation that there are more buses operating on many main corridors than are needed to provide the same level of service. There are a number of

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7. This is obviously a loose comparison, but better estimates should be available soon. The strong maintenance company has purchased another bus company and is carrying out control tests to determine the impact of its maintenance.

corridors with more than 500 buses per hour. This super-saturation on main corridors is a result of the poor integration of the bus system.

Modal Shift

Official estimates of urban passenger transport suggest that in the late 1970s about 30 percent of trips (of all kinds) in the major metropolitan areas were by private automobiles, 3 percent by taxi, 60 percent by bus and the rest by various forms of collective transport (per table 3-2).

Until 1977, the automobile fleet grew by almost 12 percent per year (per figure 3-1) nationwide, while from 1974 to 1978 the number of cars in metropolitan areas increased by almost 10 percent per year (see table 3-3). Although no estimates were available to the author, the percentage of trips taken by car clearly increased significantly over the period. Given this recent history, it is arguable that a "modal shift" in Brazil can be a stabilization or even a slowing down of the trend towards increased car use as well as a shift from current levels of use If, for example, 35 percent of metropolitan passenger trips were by car in 1995 after fifteen years of good economic growth, this would certainly represent an important shift in modal trends, even though the percentage of trips by car had increased.

Given the paucity of reliable information, any discussion of modal shifts during the 1973/74-1979/80 period must be impressionistic. In general, it appears that there was relatively little change in pre-existing trends despite a number of measures and disincentives to car ownership and use. The one exception to this observation may be the metropolitan area of Curitiba, where it is claimed that the percentage of passenger trips taken in private cars actually fell from about 40 percent in 1970 to 30 percent in 1981, due to a massive improvement of the bus system. It is beginning to appear, however, that from 1980 the rate of expansion of the role of the automobile in urban transport will decrease significantly, though not as drastically as government targets propose (table 3-2 shows official projections).

A key factor for this prognosis is the large decline in the rate at which new car production has expanded, both in absolute terms and relative to economic growth. Between 1969 and 1974 new car production expanded at a

Table 3-2. Passenger Transport in the Metropolitan Areas - By Mode

Transport mode	1977 Trips per day thousands	1977 Trips per day percentage	1985 Trips per day thousands	1985 Trips per day percentage	Percentage of new growth	Rate of growth (percent continuously compounded)	Rate of growth 1977-85 (trips per day in thousands)
Private automobile	10,448	29.1	10,655	20.0	1.2	0.25	207
Taxi	1,214	3.4	2,664	5.0	8.3	10.3	1,450
Bus	21,807	60.8	29,424	55.2	43.8	3.8	7,617
Trolleybus	290	0.8	2,000	3.8	9.8	27.3	1,710
Urban railway	1,483	4.1	8,235	15.4	38.8	23.9	6,752
Boat	174	0.5	303	0.6	0.7	7.2	129
Other	470	1.3	--	--	--	--	(-470)
Total	35,886	100.0	53,281	100.0		5.1	17,395

Source: "O governo acorda para os suburbios," Transporte Moderno (São Paulo, Dezembro 1979), pp. 16-22.

Table 3-3. Growth of Vehicle Fleet in Major Metropolitan Regions and Their States, 1974-1978

Metropolitan region or state	1978 Number of autos (000)	Percent change 1974-78	Absolute increase (000)	1978 Number of taxis	Percent change 1974-78	Absolute increase (000)	1978 Number of[a] buses	Percent change 1974-78	Absolute increase (000)	1978 Number of mixed-use camionetas (000)	Percent change 1974-78	Absolute increase (000)
Belem	21.7	127	12.2	3,175	103	1,609	927	136	534	9.9	168	6.2
Para	23.5	133		3,399	109		1,126	169		11.4	180	
Fortaleza	45.5	61	17.3	3,631	6	194	1,650	42	484	23.7	129	13.4
Ceara	56.7	80		4,912	25		2,062	48		37.9	119	
Recife	87.7	56	31.5	6,027	-5	(-310)	2,632	43	792	37.6	156	22.9
Pernambuco	111.1	67		7,779	5		3,239	45		59.4	142	
Salvador	70.5	62	27.1	6,467	52	2,210	2,125	297	1,590	33.5	181	21.6
Bahia	112.4	83		9,408	53		4,087	207		64.9	158	
Belo Horizonte	128.4	59	47.8	5,571	5	282	3,933	45	1,226	59.7	157	36.5
Minas Gerais	367.2	79		12,234	17		10,800	57		189.3	135	
Rio de Janeiro	545.0	27	115	18,139	-14	(-2,862)	14,485	32	3,491	200.5	126	111.8
Sao Paulo	1,089.3	21	186.4	33,717	-14	(-5,474)	19,946	25	4,017	512.4	107	264.8
Sao Paulo	1,767.0	27		46,385	-12		31,892	26		858.6	97	
Curitiba	108.7	41	31.3	2,247	-6	(-137)	2,195	22	392	43.7	80	19.5
Parana	304.7	46		7,464	-10		6,106	15		154.4	60	
Porte Alegre	170.8	38	46.7	4,760	-16	(-899)	3,066	8	239	59.5	94	28.9
Rio Grande do Sul	414.8	51		9,871	-8		6,980	16		163.2	81	
Total metropolitan regions	226.8	29	515.3	83,734	-6	-5,387	50,959	33	12,765	981	116	525.6
Total increase in Brazil			1,286									1,044

Source: Empresa Brasileira de Planejamento de Transportes--GEIPOT, Anvaric Estatistico dos Transportes--1980 (Brasilia, Ministerio dos Transportes, Dezembro 1980).

[a] Includes urban and interurban buses.

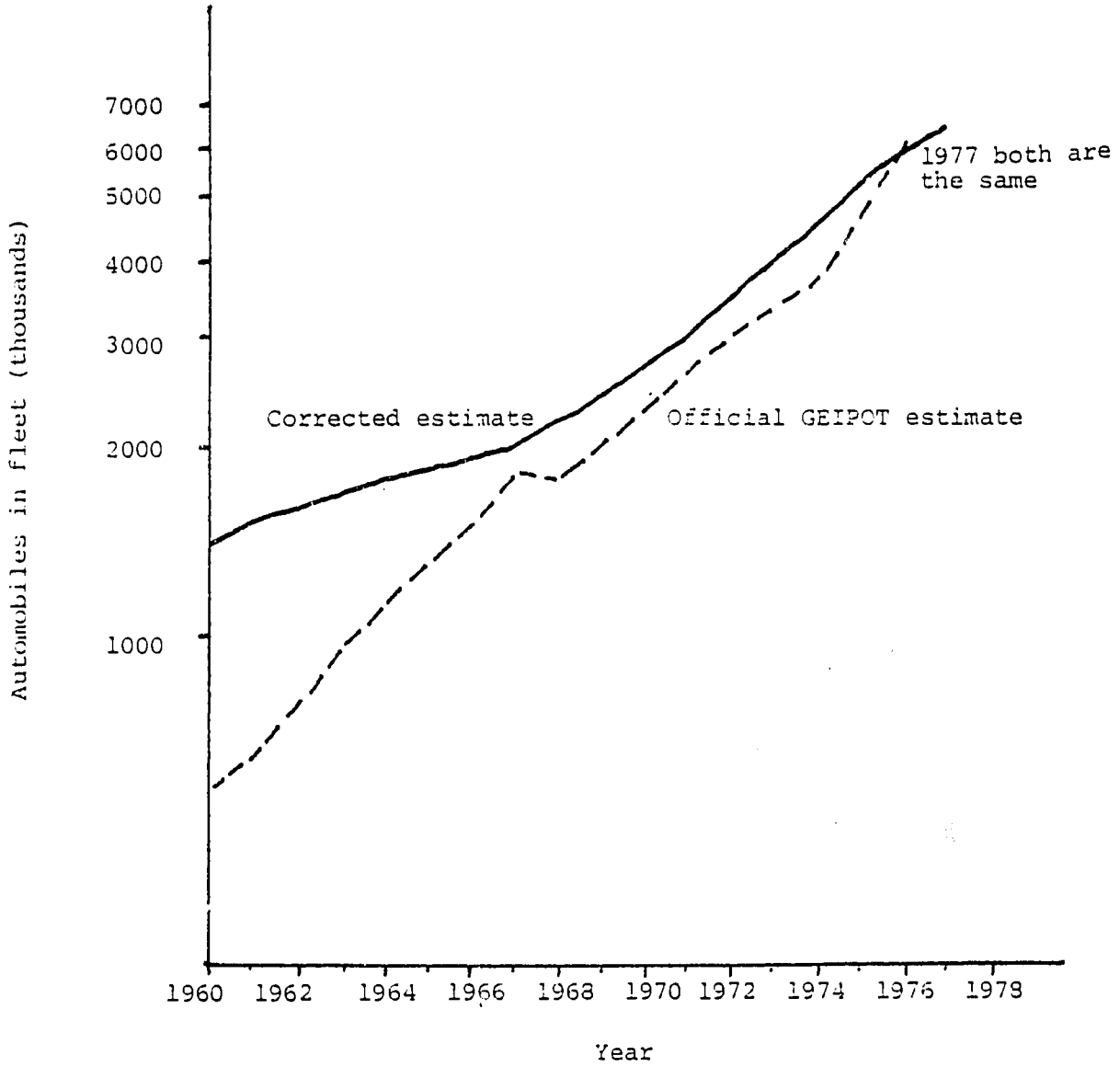


Figure 3-1. Estimate of estimated national automobile fleet (1960-1977)

Source: Empresa Brasileira de Planejamento de Transportes--GEIPOT, Estudo da Frota National de Veiculos (Brasilia, Ministerio dos Transportes, Junho 20, 1979).

rate of about 25 percent per year relative to a GDP growth of 11.5 percent per year. From 1974 to 1979, new car production expanded at about 5 percent per year relative to a GDP growth rate of 6.3 percent. It appears that at least through 1977, this slowdown was only very weakly reflected in the rate of expansion of the automobile fleet as discussed in the introduction of this paper.

However, the impact of slower growth in production must eventually be felt in fleet statistics, and the deceleration of the automobile industry has continued. In 1980 output rose only about 3 percent, less than half the rate of GDP growth (see figure 3-2). In 1981, a year of economic crisis in which the GDP growth is estimated to be -2.0 percent, new car production appears to be about 30 percent below the 1980 level. In addition to this visible slowdown, an increasing fraction of production is destined for export (see figure 3-2). Automobile manufacturers in mid-1981 were not very optimistic about medium term domestic growth prospects. In a decade, then, Brazil has gone from a situation where the rate of increase of automobile production has fallen from twice the rate of GDP growth to a rate below that of GDP; perhaps, during much of the 1980s, as little as one-half. The auto industry has, for the time being, ceased to be the leading edge of Brazilian industrialization, unless it can continue to rapidly expand exports.

Why did this slowdown take place? How important were government policies? The author's guess is that market saturation played an important role. By the mid-1970s, Brazil had a per capita car ownership (60 per 1,000) comparable to that of Italy in the early 1960s and Japan in the late 1960s. With a lower per capita income and a more skewed income distribution it is quite possible that the part of the market capable of affording cars approached saturation. This idea is strengthened by the observation that the major market segment for continued expansion, the 60-80 percentile of the population in terms of income, fared more poorly during the 1970s than those above or below them on the income scale.

Taxes on gasoline may also have had an effect. Table 3-5 shows the retail price of gasoline, which has risen substantially in real terms since the early 1970s. It is interesting to observe, however, that the cost of

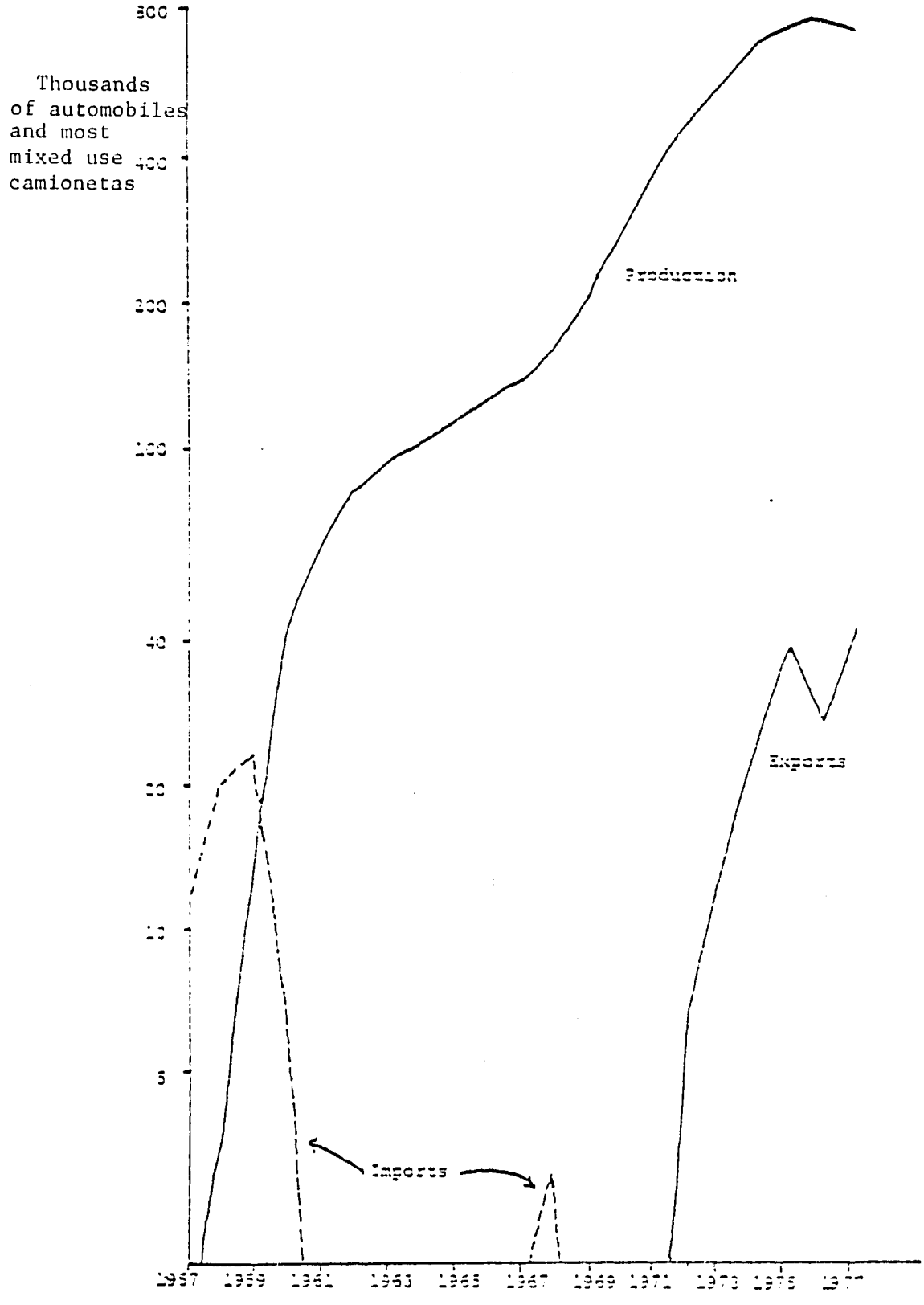


Figure 3-2. Automobile Production, Imports and Exports, 1957-1977.

Source: Empresa Brasileira de Planejamento de Transportes--GEIPOT, Estudo da Frota National de Veiculos (Brasilia, Ministerio dos Transportes, Junho 20, 1979).

owning and operating a new car fell rather steadily during the 1975-1980 period, despite higher gasoline prices (table 3-4). This is because fixed costs declined steadily, due primarily to lower new car prices, as did maintenance costs, as estimated (table 3-5 and figure 3-3) for fleet cars in the upper, middle, and lower price range (Opala, Corcel and VW 1300 sedan). Unfortunately, the author does not have pre-1974 estimates for operating costs.

The purchase price of a car is generally regarded as a dominant factor in consumer decisions, more important than fuel price. While the rate of decline of real new car prices in 1975-1980 may have been slightly slower than in the pre-1974 period (see partial data in table 3-6), it seems unlikely that such an apparently small change could have such a dramatic effect.

Disincentives to the use of cars owned are another way to encourage a modal shift to collective transport. Unfortunately, the author could find no basis to determine the extent to which this took place during the period. The sharp drop in gasoline consumption per light vehicle between 1972 and 1976 can be ascribed to the shift from gasoline to diesel light trucks, more complete registration of vehicles in later years, and the diminishing role of taxis, as can be seen in table 3-3. Taxis fell from 4 percent to 2.5 percent of the metropolitan car fleet between 1974 and 1978, but they are still estimated to consume up to 10 percent of the gasoline. The overall impression is that until 1980 there was rather little drop in urban car use.

Measures to reduce automobile use to encourage a modal shift are hard to conceptually distinguish from measures to reduce the amount of overall transport, especially when the measures affect optional trips. In these cases the car owner may simply change his behavior to travel less rather than take collective transport.

Brazil has employed a variety of measures. The most important of these is the tax on gasoline. Brazilian gasoline now costs about $3.00 per gallon (at official exchange rates). This high price, combined with an income squeeze on the salaried middle class, appears subjectively to be having an impact on urban trips by car in the 1980/81 period. The price prevailing throughout most of the 1974/1979 period, about $2-2.25/gallon, however, appears to have had only limited effect.

Table 3-4. Total Operating Costs of Fleet Cars, 1975-1980
(total cost per kilometer, cruzeiros of July 1980[a])

	1975[b]	1978[b]	1979[b]	1980[b]	1981[b]	Production in 1973 (thousands)	Production in 1978 (thousands)
VW 1300, sedan	9.87	9.29	8.92	8.20	9.10	95.3	162.5
Corcel, basic two-door	11.73	12.18	11.76	10.37	13.22	53.7	81.6
Opala, 4 cylinders	14.35	14.84	14.62	14.40	15.44	49.7	42.0
Dart, luxury coupe	18.82	20.68	20.18	20.63	--	15.4	0.9
Passat LS, two-door	--	14.00	13.68	11.84	14.07	--	89.6
Chevette	--	12.68	11.82	10.65	11.32	31.7	87.1
Brasilia	--	11.08	10.82	9.12	10.45	34.7	159.2
Fiat 147	--	9.95	10.15	8.71	9.60	--	88.9
VW 1300 sedan--alcohol	--	--	--	7.13	8.65	--	--
VW Gol	--	--	--	9.81	10.72	--	--
Fiat 147--alcohol	--	--	--	8.08	9.07	--	--

Source: Transporte Moderno automobile operating cost estimates: "Os custos de 21 automoveis," Transporte Moderno (Agosto 1981), pp. 24-33; "Quanto pagar pelo quilometro rodado," Transporte Moderno (setembro 1975), pp. 39-42; "O custo operacional de doze automoveis," Transporte Moderno (Junho 1979), pp. 38-42; "O custo operacional de 16 automoveis," Transporte Moderno (Agosto 1980), pp. 26-30; and "As taxas de reembolso para dez automoveis," Transporte Moderno (Julho 1978), pp. 73-77.

[a]Cost includes: depreciation, return to capital, licensing, insurance, maintenance, tires, fuel, oil, washing/greasing, assumes 1500 km/month average.

[b]For indexing prices, following months used: 1975-August, 1978-June, 1979-May, 1980-July, 1981-July. This is the month prior to the edition.

Table 3-5. Cost Components Per Kilometer, 3 Cars 1975-1980
(constant cruzeiros of July 1980)

	Fixed cost per km[a]				Fuel cost per km[b]				Maintenance cost per km			
	1975	1978	1979	1980	1975	1978	1979	1980	1975	1978	1979	1980
VW 1300 sedan	3.44	3.03	2.86	2.26	1.90	2.27	2.01	3.35	1.60	1.55	1.59	1.16
Corsel, two-door	5.15	5.71	5.02	3.84	1.80	2.15	1.90	3.17	2.00	2.06	1.83	1.52
Opala, 4-cylinder sedan	6.20	6.12	6.11	4.82	2.90	3.46	3.07	5.12	2.27	2.26	2.25	2.11

Source: "Quanto pagar pelo quilometro rodado," Transporte Moderno (Setembro 1975), pp. 39-42; "O custo operacional de doze automoveis," Transporte Moderno (Junho 1979), pp. 38-42; "O custo operacional de 16 automoveis," Transporte Moderno (Agosto 1980), pp. 26-30; and "As taxas de reembolso para dez automoveis," Transporte Moderno (Julho 1978), pp. 73-77.

[a] Assumes 1500 km per month; return to capital not included; straight-line depreciation over four years to resale value in São Paulo.

[b] Assumes 1980 fuel use coefficient.

Table 3-6. Average Price of Some Major Models of Vehicles Produced in Brazil
(price constant 1973 cruzeiros)

Model	Type/vehicle	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	Annual rate of change, first 2 years to 1977 (percent)
FNM														
FNM 180 M3 [d]	heavy truck	--	--	--	--	--	146.4	130.0	--	111.1	122.4	125.0		3.2
Ford														
Corcel 2-dr. luxe [a]	car	--	--	29.9	28.0	26.1	25.3	24.4	--	23.6	21.9	21.3	4.2	
4-dr. luxe	car	--	--	30.1	28.2	26.0	25.7	24.6	--	23.7	22.1	21.4	4.2	
F-600 gasoline	medium truck	50.2	50.0	47.2	44.9	45.1	44.5	42.3	--	40.6	37.3	36.9	3.1	
F-600 diesel	medium truck	67.9	69.4	64.4	60.0	59.7	53.3	57.7	--	52.0	47.7	52.6	2.6	
F-75	pickup	--	--	25.8	24.2	21.9	23.3	22.5	--	22.1	20.1	25.6	0	
General Motors														
Opala 4-C, 4-dr. special	car	--	--	30.8	30.8	27.0	25.8	26.4	--	26.6	25.5	26.0	2.1	
Opala 4-C, 2-dr. special	car	--	--	--	--	29.6	26.8	27.7	--	26.5	25.7	25.8	2.3	
Chevette	car	--	--	--	--	--	--	22.0	--	21.0	20.0	18.9	3.8	
Chevrolet C-1404	car	--	--	39.1	36.5	34.5	33.3	32.4	--	31.3	27.9	27.8		4.3
Chevrolet D-6803	medium truck	--	--	60.4	64.0	54.5	51.7	55.4	--	52.4	44.1	46.6	4.8	
Mercedes Benz														
L1313 [b]	semi-heavy truck	--	--	--	88.6	83.9	95.3	83.6	--	78.6	74.2	72.1	2.9	
O-362-H/Ill. Rodov.	bus	--	--	--	150.3	181.0	167.8	154.3	--	161.8	150.1	163.0	--	
Saab/Scania														
L11042 [c]	heavy truck	--	--	--	--	--	174.7	157.0	--	150.4	146.2	149.2	3.2	
LT 11050 [e]	extra heavy truck	--	--	--	--	--	285.7	263.3	--	260.5	265.4	264.5	1.5	
Volkswagen														
Sedan 1300	car	27.7	22.6	21.2	20.2	18.4	17.4	16.7	--	16.4	15.0	14.7	4.3	
Sedan 1300 L	car	--	--	--	--	--	--	--	--	17.9	15.6	15.3	--	
Kombi	mixed use van	26.1	25.6	24.1	24.1	23.7	22.3	20.6	--	21.3	20.7	21.8	1.8	
Brasilia	car	--	--	--	--	--	--	21.5	--	19.8	18.1	18.8	3.4	
Variant	car	--	--	30.4	27.3	25.1	24.0	22.9	--	21.8	20.0	20.7	4.8	
Passat LS - 2 dr.	car	--	--	--	--	--	--	--	--	25.4	21.6	23.0	--	

Sources: Empresa Brasileira de Planejamento de Transportes--GEIPOT, Anuario Estatistico dos Transportes (Brasilia, Ministerio dos Transportes) for the years 1970 through 1979.

[a] In the annuario of 1974, identified as a Coupe.

[b] In annuario 1974, all L1313 grouped together from 1977/78 annuarios (L1313/42 e L 1316/42) and (L1313/48 e L1316/48) averaged.

[c] L11042 becomes L11142 e L11423 in 1978 annuario.

[d] In 1978 Fabrica Nacional de Motores becomes Fiat Diesel do Brazil.

[e] In 1978 annuario LT 11050 becomes (LT1150 e LT4150) but overlapping data unchanged.

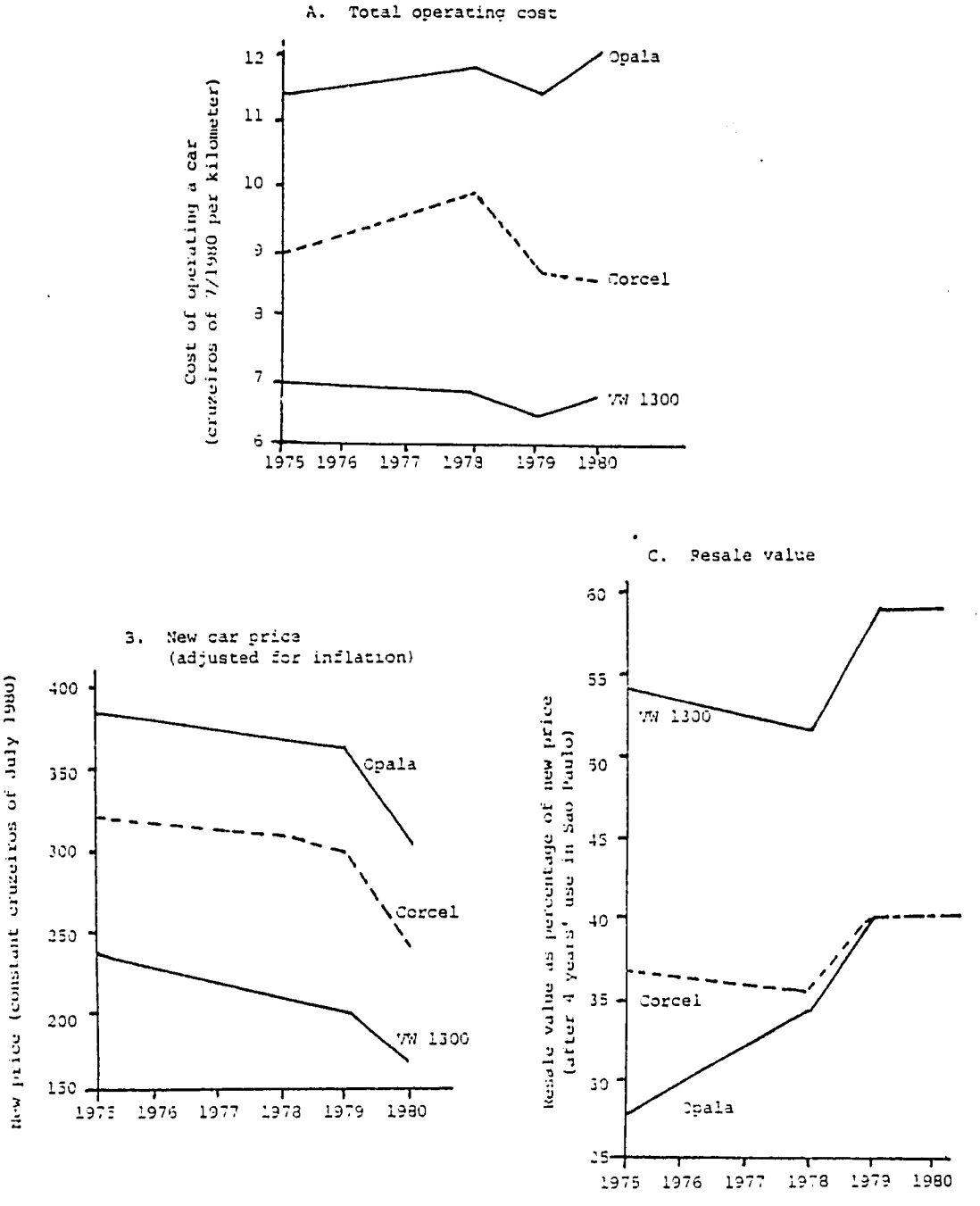


Figure 3-3. Cost Characteristics of three cars.

Source: "Os custos de 21 automoveis," Transporte Moderno (Agosto 1981), pp.24-33; "Quanto pagar pelo quilometro rodado," Transporte Moderno (Setembro 1979), pp.39-42; "O custo operacional de 16 automoveis," Transporte Moderno (Agosto 1980), pp.26-30; and "As taxas de reembolso para dez automoveis," Transporte Moderno (Julho 1978), pp.73-77.

Other disincentives have been or are being tried:

a. Tolls were increased by 50 percent in 1977. Although there was an immediate reaction, this had been lost by 1978 (no time series of deflated cost of tolls is available). Tolls are unlikely to be important for urban transport, however.

b. Closure of gasoline stations on weekends. No estimates of impact are available, but there is little evidence that it is substantial. One Brazilian review critizes this policy as excessively irritating as well as ineffective [11]. Even in theory this measure will not influence weekday driving or most urban weekend driving. The Folha de São Paulo reported that no less than 42 percent of the gasoline sold in São Paulo is sold on Fridays.

c. Speed limits. This measure has little application in urban transport. This measure was estimated, under optimistic assumption, to reduce gasoline consumption by 0.8-1.7 percent [12].

d. Prohibit private car use on certain days. This is a radical and very authoritarian prescription, and was proposed by the Minister of Transport for a test in Curitiba. The mayor, not surprisingly, resisted this exemplary honor, principally because there was no way even that city's relatively strong bus system could absorb the 40 percent surge in demand one day a week. The response of Curitiba has, however, been interesting. It is starting to legislate restructuring working hours to spread and flatten the peak "rush-hour" time and to stimulate people in different quarters of town to voluntarily not use their cars on given and different days of the week. The restructuring of work hours in Curitiba has had some success [13].

One possibly effective measure to discourage urban trips by private car owners has been almost totally ignored in Brazil. This is the control of parking to, ultimately, make it more expensive for car owners to park their cars in urban commercial districts. The government has announced plans to restrict parking in central urban areas. It remains to be seen whether or not this will actually be done and, if it is done, if it will be done effectively.

Emphasizing control of parking, especially in central areas of metropolitan regions, is an attractive car disincentive strategy for several reasons. It is highly focused and discourages particular uses of

an existing fleet more than the fleet itself. The focus is helpful because it can closely support the strengthening of collective transport. First, in areas where investments are being made to upgrade collective transport capacity and quality, parking controls can help push car owners (and potential owners) to use the improved system. This is distinct from the shotgun approach of a gasoline tax, which, while useful, may also in many cases simply raise operator costs without accomplishing a modal shift (note that a $1.50 parking cost in a 20-kilometer roundtrip is equivalent to more than a doubling of gasoline prices, insofar as the cost of that trip is concerned). Second, parking controls can help create the space which is needed for collective transport to work effectively.

Better collective transport is the carrot to the "stick" of restricted parking. A strategy here is complicated by the great income disparities which exist in Brazil between much of the current car-owning and bus-using populations. This raises a basic question. Does one attempt to get the car owner to use an "elite" form of collective transport, or does one emphasize upgrading the service to current users of collective transport in the hope of influencing future trends? Both approaches have been tried, and the experience so far has been pretty unequivocal--going straight for the car owner doesn't work well. Special lines of superior buses (frequently air conditioned, with stewardesses, piped music and coffee) operate and have survived with profit, but their ridership remains small, stagnant, and strictly commuter. Many experiments in this direction have been abandoned, most spectacularly the elite bus system of the São Paulo municipal bus company CMTC in the Jardins.

On a larger scale, it appears that an important planning criterion for the metro system of São Paulo was to get car owners out of their cars. This may have influenced the decision to build the north-south line before the east-west line, as the north-south line serves a considerably more affluent part of the city where car ownership is higher. As stations were opened, frequent reference was made to the estimated number of motorists drawn to the system.

In economic terms, the north-south line has not been a success. Fares are more than 80 percent subsidized and rush hour ridership (30,000 per direction per hour) is about one-half of the expectations (which was below the break-even point). No one denies that the east-west line will carry

far more passengers. The problem is that few of them drive cars. They just need better collective transport.

This is exactly the point from which an alternative strategy begins. Improving the collective transport system for existing users is receiving increased attention, primarily for reasons having to do directly with the system's social-political impact rather than as a modal shift strategy.

However, despite some successful isolated initiatives, the general situation or tendencies of collective transport policy have remained the same since 1973/74, and continue to be forcefully defended, for example, during extensive debates at the 1981 São Paulo seminar on politics and legislation [14].

Bus systems, which provide 90 percent of urban collective transport and are mostly privately operated, continue to provide service characterized by:

- an irrational distribution of lines;
- overcrowding;
- frequent breakdowns;
- slow operating speed;
- non-fulfillment of schedules, especially first and last runs;
- poor maintenance procedures;
- almost total lack of cost control procedures; and
- poor management.

In brief, the service is incompatible with Brazil's level of development and stands in sharp contrast to the intercity bus system, which is relatively well managed [10]. Nationalization is not necessarily the answer. The publicly owned companies are as inefficient as the privately owned companies. What is refreshing, at least, is that the industry is increasingly aware of the problem, aware essentially that times are changing.

The situation of the state-owned rail systems is, with the exception of the specially favored metros, even worse. Rail transport is important only in São Paulo and Rio, and, again with the exception of the metros, serve some of the poorer suburbs at the periphery of these cities. The service is heavily subsidized (it costs 5 cents to go 20 kilometers) but is very poor. Vandalism, both routine and in outbreaks by outraged riders, is common.

The urban railways are the principle focus of the government's policy to improve urban transport over the next four to five years. Existing suburban passenger lines and other rail lines in seven metropolitan areas (São Paulo, Rio, Porta Alegre, Belo Horizonte, Salvador, Recife and Fortaleza) are being upgraded to pre-metro status. The ambitious nature of this program is reflected in the objectives for metropolitan trips in 1985 (see table 13). Urban rail is projected to expand six-fold. Unlike many official projections, which tend to have a short lifetime, this one has persisted for some time now, and, more importantly, the goverment is standing behind completion of the program more or less on schedule.

There is much that is attractive in this $400 million per year federal program. It reflects a much better sense of reality and priorities than the earlier fascination with metro systems. Criticisms are, however, emerging. There is a practical debate beginning here which could hold considerable interest for future policy making both in Brazil and elsewhere.

The principle question is whether this program is diverting attention and resources from an urgently needed and broader upgrading of the urban bus system. While no one contests the need to drastically improve existing suburban railway systems in São Paulo and Rio, is the approach which has been chosen, which involves costs in excess of $10 million/kilometer cost effective? In other cities, will the upgraded rail lines really serve the mass of the population as effectively as a similar level of investment in upgrading the bus system? There is in fact a substantial line item in the federal alternative transport program for upgrading bus services (about $150 million per year--see table 2-6), but there is more than a hint of suspicion that these investments will not actually be made, especially the crucial ones for roadway improvement. They have a lower priority and, given the budgetary problems of the government, are likely to be quietly interred.

The debate is embryonic. It will not deflect the government program, and it is certainly beyond the capability of the author today to judge whether it should. There is too little information and analysis openly available to judge. Why then is it interesting? Because of the experience of Curitiba in upgrading its bus system, and because some of the most thoughtful transport analysts think that building from that experience

would be more cost effective and finally, because the government program is not so obviously irrational. One is reminded of the Olympic slogan, "belle la victoire, mais plus belle la bonne lutte." Let us, then, conclude this work with a discussion of Curitiba's innovative system.

The Experience of Curitiba

Curitiba is the capital of the state of Parana, the most important grain producing state of Brazil. It is a rapidly growing, prosperous city with a contiguous metropolitan region of about 1,400,000. Although it is not a city which was planned from its inception, it is unquestionably the best planned city in Brazil and quite possibly in the developing world. Insofar as expanding from its experience is concerned, though, this is almost a curse. There is a tendency in Brazil to regard Curitiba as sui generis.

In the mid-1960s the city was beginning to experience problems of congestion and traffic saturation in its urban core. This led to the adoption of a plan to encourage incipient commercial growth along radial axes coming out from the center, rather than concentric growth. In support of this strategy the city developed an adequate transport infrastructure along the axes, along with the tool of land use zoning.

The transport plan for these axes had two principle objectives. The first was to improve traffic circulation transport to handle large flows of passengers as efficiently as possible with a minimum investment cost. At the time that Curitiba was engaged in planning, a number of U.S. and European bus manufacturers were seeking to demonstrate with various pilot experiments that bus systems were perfectly feasible for mass transit without the heavy investment in rail systems. The system adopted in Curitiba was based on this work. To the author's knowledge it is the only full-scale test of the concept of a mass transit system using buses in the world.

The basic idea was to implant permanently and completely exclusive bus lanes, usually in the center of the road (see figure 3-4). This road within a road is called a canaleta. What distinguishes the canaleta from many exclusive bus lanes is that it is very securely isolated from all other traffic. The 100 kilometers of exclusive lanes in São Paulo, for example

(which occupy the curbside lane and are usually not physically separated from the rest of the road), are subject to numerous interruptions such as cars leaving parking lots, right-hand turns, and taxis stopping to pick up or leave passengers. The key starting point for this action was a shift in mentality to view collective transport as a true priority service to the public, and the realization that the first key to satisfactory performance of a surface transport system is roadway space.

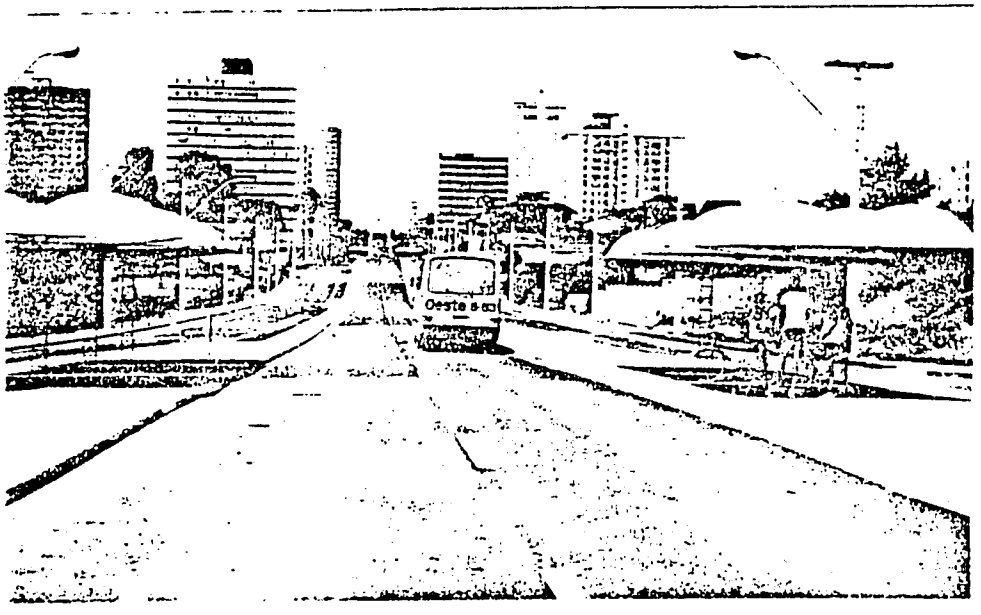
Detailed planning began in 1972. In 1974 operation of the system began with new lines being continually added. Table 3-7 shows the evolution of ridership over time. The system now includes 56 kilometers of canaletas with covered stops approximately every 400 meters.

Table 3-7. Evolution of Bus Mass Transit System in Curitiba

Year	Express lines	Feeder lines	Circular lines	Extension of canaletas (km)	Passengers/day using express system (000)
1974	2	8	0	19.8	45
1975	2	11	0	--	67
1976	3	19	0	--	95
1977	4	21	0	--	125
1978	7	33	0	31.6	190
1979	9	33	1	44.7	207
1980	14	52	4	49.3	348
1981	14	52	4	--	360
1982	17	63	4	56.0	450
Completion of current plans	16	150	--	--	624

Source: Prefeitura de Curitiba, Medidas para economia de combustivel--prospeta de Curitiba (Curitiba, Brazil, 1980/81).

The express lines are only one element of an integrated system. There are in addition numerous feeder lines and four circular lines. The feeder lines bring passengers from neighboring areas to the express line, while the circular lines (called inter-barrios) allow longer-range circumferential movement at various distances from the center of the city. Both the feeder and circular lines connect with the express lines only at the same specially designed "terminals." These terminals are closed so that anyone entering the platform has already paid his ticket while those



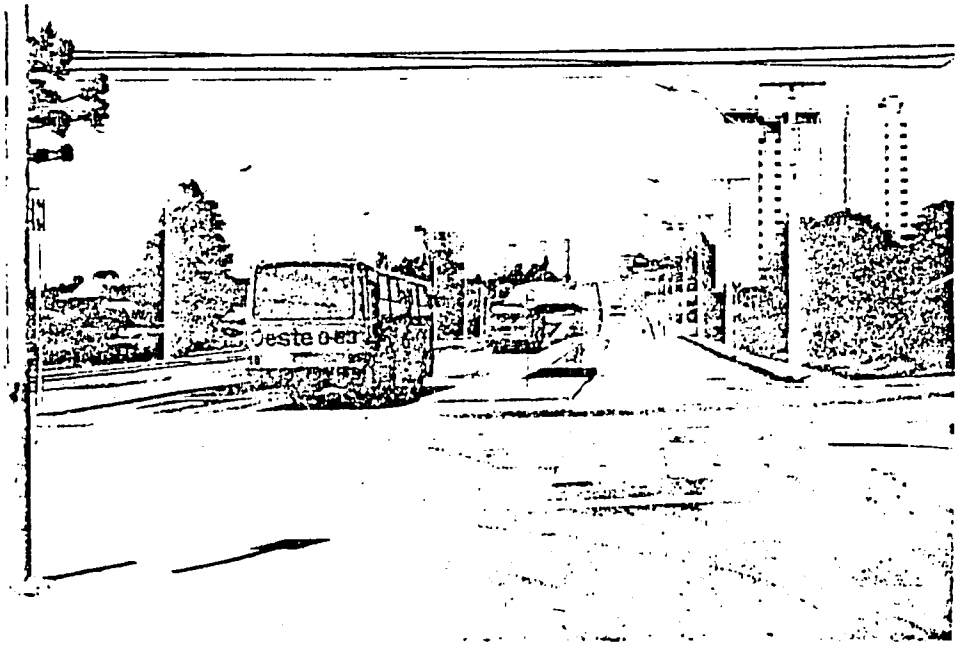


Figure 3-4. View of physical infrastructure of an express line (Integrated Bus System of Curitiba)

Source: Prefeitura de Curitiba, Medidas para economia de combustivel--a proposta de Curitiba (Curitiba, Brazil, 1980/81).

transferring buses can also embark without further payment. The terminals resemble a well-kept suburban railway or surface metro station with the novelty that it is buses which are entering and leaving. The terminals have a far more intimate integration of the express line with other lines than an analogous railway with its feeder buses. You step off one bus, walk fifty feet down the platform and step on another. The half a dozen different lines entering a terminal within a few minutes vividly illustrate the flexibility and integration of the system. Figure 3-5 shows the current layout of the express and circular bus lines, together with the terminals where they connect.

A prominent aspect in the planning of the integrated system is the attention paid to saving time. This is due in part to the system requiring passengers to change buses to reach a destination much more than is habitual in Brazil, where cities generally have a multitude of lines, each without any integration (via transfers) to another. This prompted planners to be very aware of trip time in arranging the system in order to overcome consumer resistance. Time is also important if there is to be any competition with private cars. The emphasis on saving time is evident in the design of the canaletas and the terminals which have already been discussed. Additional measures are [8, 15]:

1. Computer controlled synchronization of traffic signals in the central area;

2. Outside of the central area, vehicle actuated signals with priority for express buses. On one line this reduced bus stops for signal changes by half. Buses stop only 27 percent of the time and then only for an average of 2.7 seconds. Angular collisions were reduced 50 percent.

3. Automatic fare collection. Passengers purchase tickets in advance and they are cancelled by a machine in the bus on entering the front. The system was partially begun in late 1980 and results in a 7.5 percent reduction in average time for express buses due to faster embarkation. It is planned that all stops on the express lines will have a ticket seller.

Although the emphasis in Curitiba has been, and remains, institutional and structural planning, the city has been advancing the state-of-the-art of bus technology and layout in Brazil as well. The first stage was to go

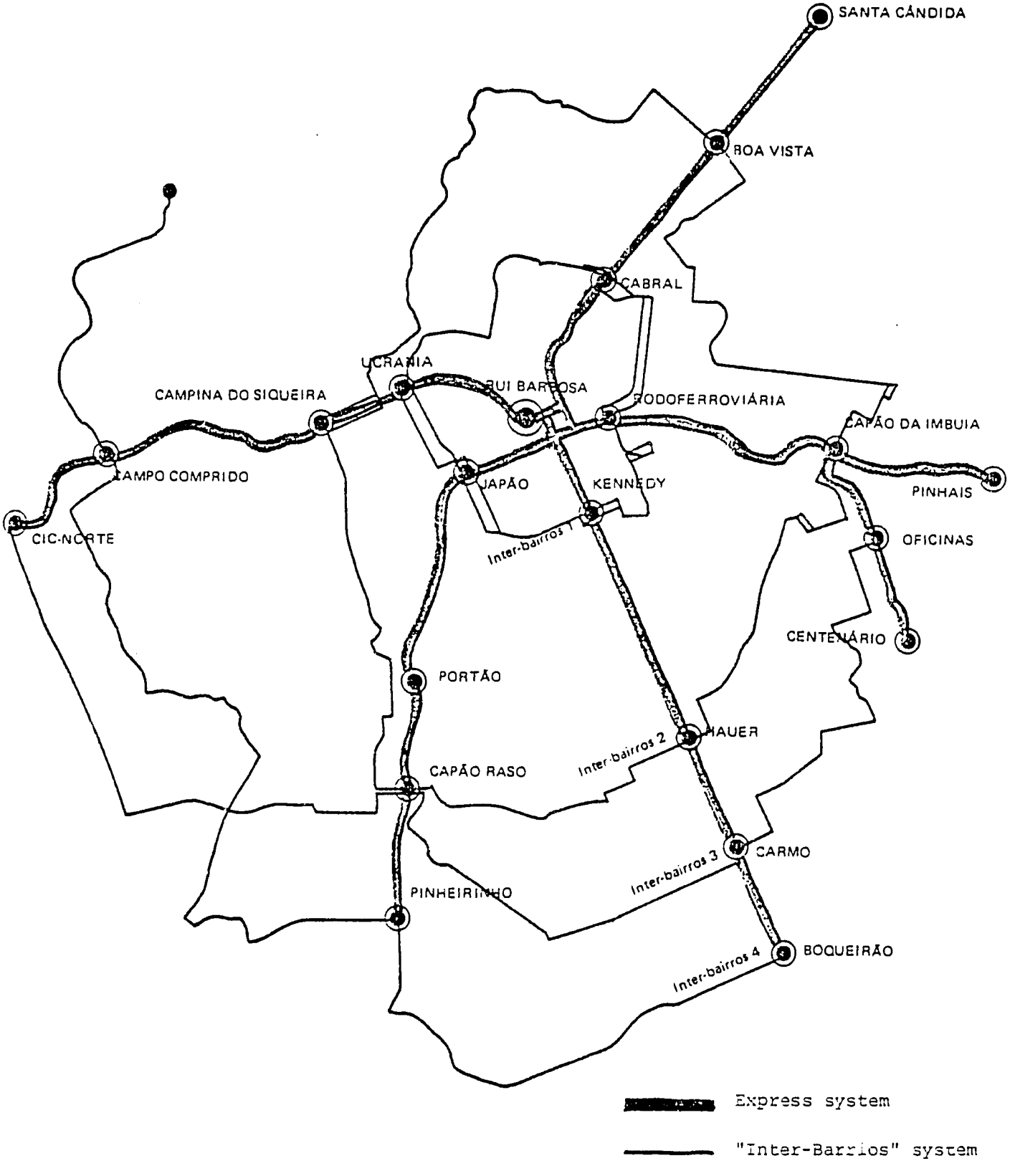


Figure 3-5. Integrated Bus System of Curitiba

Source: Prefeitura de Curitiba, Medidas para economia de combustivel--a proposta de Curitiba (Curitiba, Brazil, 1980/81).

to a rather larger bus for the express lines, which also had larger doors and lower steps for easier entry and exit. Articulated buses holding more than 200 passengers are now entering operation. Passengers enter by the front door in those buses adapted for automatic ticketing. The interior is planned for maximum standing room and ease of circulation of passengers with seats arranged mostly back to the wall, distinct from the usual arrangement of two sets on either side of the aisle.

With the standard 100 passenger buses, flows of up to 12,000 passengers per direction per lane per hour can be achieved at an average velocity (including all stops) of 22 km/h (some estimates are as high as 32 km/h, [16]. Equipped with articulated buses the capacity can be increased to 18,000 without innovation. Some analysts think this could be increased to 30,000 if electric trolleybuses were used. This upsets the traditional load hierarchy, which is roughly:

bus, trolleybus	3,400- 4,000 passengers/hour in a direction
rail trolley	6,000-10,000 passengers/hour in a direction
light-metro	12,000-18,000 passengers/hour in a direction
metro	20,000-60,000 passengers/hour in a direction.

What is particularly significant, however, is that the investment in the express bus system is significantly lower. It was estimated to be less than $2 million per kilometer including all costs of construction, land appropriation, terminals and vehicles. Pre-metro projects in Brazil are running at $10-20 million per kilometer, while metros are in the $50-75 million range.

Curitiba is not, however, wedded to buses. At a minimum the system will be largely electrified in a few years, with electric trolleybuses. This should not only reduce costs and save fuel (high density routes are ideal for electric trolleybuses), but reduce air and noise pollution. There is also some planning for rail trolleys on several of the more heavily travelled lines, although costs may be prohibitive. Perhaps the key point here is that opting for the lower cost express bus option did not close the door on the adoption of rail systems later. Indeed it has made their establishment easier if and when traffic flows justify them...space, routes, and patterns of freer integration have already been established.

The integrated bus system does not handle all bus transit in Curitiba. There are buses operating on a short circular route in the center, selective "elite" buses linking high income neighborhoods near the center to the center,[8] and a special line serving the universities. There are also conventional lines. Together they handled about 48 percent of collective transport (or about 330,000 passengers/day) in 1981, with conventional lines responsible for much the greater part of that. This share should fall to about 40 percent in 1982 and further as the integrated system is put in place by adding feeder lines to the existing express lines (see table 3-7).

All these different kinds of lines are color-coded for easy recognition. For example, express buses are red, inter-barrio circular buses green, central city circular buses white, and so on. Since the majority of bus users are at least minimally literate, most stops on the integrated system have bus route maps. This is a thoughtful, if obvious, additional step to make the system more accessible to users, though the conventional wisdom has it that poor people in developing countries can't understand maps, even if they can read.[9]

The greatest beneficiaries of the development of Curitiba's bus system have been the poorer economic strata. There are several reasons for this. The predominant users of collective transport are almost by definition the poorer two-thirds of the population. Any improvement in the quality of service automatically rebounds to their benefit. It is sometimes forgotten what an enervating process collective urban transport can be. Enervating is certainly what it usually is in most Brazilian metropolitan areas. The integrated bus system has increased the reliability of transport, the comfort, and, more subtly, the dignity of the user of urban buses. It has also decreased trip times, and the economic cost. This last item is

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8. This elite system carries about 6,000 passengers per day, of whom one-third are estimated to have given up using private cars for commuting. These represent about 1 percent of the collective passenger trips per day and 0.5 percent of the cars respectively.

9. Maybe it is because they almost never see maps in a situation where they might use them. Judging from the way bus transit authorities behave throughout most of the developed world, it would appear that they don't believe most of their riders understand or can use maps either.

perhaps the most important, though the others should not be underestimated, particularly if one thinks in longer term modal trends.[10] In the longer term, when median incomes are hopefully higher than today, most people's decision on whether to drive or ride will be based on the quality of service than on whether each trip costs 35 cents or 45 cents, since either cost will likely be far below the economic cost of operating a car. But, given the population which the system serves today, cost is terribly important.

The National Association of Public Transport (of Brazil) estimates that average urban bus fares (two-way) increased from 5.8 percent of the minimum wage in 1961 to 9.3 percent in 1970 which remained constant until 1978, but jumped to 11.2 percent in 1980 [10]. Since 1980 fares have increased faster in response to fuel pricing and macro-economic policies, leading to an almost 10 percent drop in bus ridership in Rio de Janeiro in 1981. The fare increases also led to 700 buses being vandalized in Salvador in a spontaneous wave of popular dissidence. Since the poorest people tend to live further from their workplace and hence pay more to get there, these averages underestimate the cost to them without even considering that people do not only travel to work. In many poor metropolitan families transport requires 20-25 percent of income.

In Curitiba the impact of bus transport costs on the poor is less than anywhere else in Brazil. First, the system is low cost. The average fare cost is one of the lowest in Brazil[11] despite the fact that wage levels are among the highest in the country (wages are about 45 percent of total bus operating costs in Curitiba) [13]. Relative to the regional minimum wage

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10. Planners in Curitiba pay considerable attention to intangibles such as aesthetics which contribute to a sense of well-being in the user, even though they increase the cost of the system a little. This is one reason they are seriously planning to put in rail lines, literally to make the user feel more gratified, classier, "up" to use public transport. Unfortunately, this may increase the cost of the system more than a little (though they claim not). The author feels that they may have underestimated the extent of their achievement in increasing the intangible desirability of bus use.

11. The average fare in Curitiba is 19 cruzeiros, or 16 cents. The author has found no lower average fare in any Brazilian city of more than 500,000 inhabitants, though his coverage is incomplete.

it is the lowest in Brazil [14]. This low average cost is a direct result of comparatively high efficiency resulting from the system improvements, and the greatest system improvements have been for those who travel furthest who, again, tend to be the poorest. Second, the average fare is the only fare. This once again favors the poor, who normally pay more for their longer trips.

A reader might conclude that the system just described is operated by a state corporation operating efficiently under enlightened guidelines. However, in Curitiba all urban transport services are provided by private operators. This is archetypical for Brazil, where at least 80 percent of urban transport is privately supplied. Not the least of the achievements of Curitiba is the successful resolution of the institutional minefield of organizing and integrating the profit-making bus companies. In general, each company is the sole provider of services in a region of the city except for "inter-barrios" lines which have a pool arrangement. The single tariff, irrespective of trip length, and the free transfer from line to line require a practical, mutually agreed on formula for compensation of companies that lose by those that gain. This is done every day.

Although the system is privately operated, the role of the state is not small. In terms of infrastructure alone it provides an indirect subsidy to the integrated bus system of at least one-third of the cost charged to consumers (although this is small compared to the subsidy to existing urban rail systems which range from two to five times the charged cost). Unlike many subsidies, however, this one <u>increases</u> the efficiency of the private operator.

The regulatory body of the city also has considerable capability for regulation, surveillance, and analysis. A strong, technically competent public authority is essential for the successful development of a privately operated system. An important result of Curitiba's experience is that the documented efficiency advantages of private sector operation at the firm or micro-level have been reconciled with the necessities of global planning and integration required for an efficient metropolitan system.

How translatable is the pioneering experience of Curitiba? It is too early to judge. Differences in urban layout, not to mention political difficulties, make the paradigm problematical. However, some cities in

Brazil are at least seriously considering it, and one major metropolitan area, Recife, is beginning to use some components of the Curitiba model. These experiences, including that of Curitiba, will deserve close study from transport planners elsewhere in the developing and developed world.

Appendix A

APPROXIMATE DERIVATION OF TRANSPORT ENERGY GROWTH IN RELATION TO GDP

The objective was to calculate the change in energy use for surface transport (ΔE_T) relative to the change in Gross Domestic Product (ΔGDP) over the periods 1969-1973 and 1974-1979. GDP estimates are shown in table A-1.

There is no authoritative time series that gives the use of fuel by sector over this period. Indeed, there is considerable disagreement among breakdowns available today. Tables A-2, 3, 4, and 5 should abundantly illustrate this point, especially for diesel. Estimates of the fraction of diesel consumed by the transport sector are 71 percent in A-2, 82 percent in A-3, 84 percent in A-4, and 90 percent in A-5. For this estimate 75 percent has been assumed. For gasoline there is more consensus (around 98 percent in transport). All fuel alcohol is used for transport. This leaves fuel oil, basically consumed for shipping. This is assumed to be 11 percent from table A-3. Aviation was not considered.

These breakdowns for 1979/80 have been held constant back to 1969. For gasoline and alcohol this poses no problem. For fuel oil this assumption probably systematically overestimates growth in both periods. For diesel, this assumption almost certainly underestimates growth in the 1974-1979 period due to the significant shift from gasoline to diesel trucks (adding a whole new demand) The only time series for diesel available shows a modest increase in transport's share 1974-1979/80 [18].

The growth of consumption of gasoline, diesel and alcohol is shown shown in table A-6. Fuel oil is not shown but is taken from reference 19. The results for the transport sector (surface only) are shown below in terms of thousands of tons of petroleum equivalent:

	Percent of fuel in transport	1969	1973	1974	1979
Gasoline	(97%)	6,400	10,187	10,475	11,443
Diesel	(75%)	3,715	6,083	6,731	11,022
Alcohol	(100%)	24	233	143	1,681
Fuel oil	(11%)	714	1,073	1,186	1,615
Total		10,853	17,576	18,535	25,761

If we compare the increase in transport fuel with the increase in GDP, we find that between 1969 and 1973 E_T increased 62 percent and GDP 57 percent for a ratio of 1.09. Between 1974 and 1979 E_T increased 39 percent and GDP 36 percent for a ratio of 1.08. Because of the importance of diesel in the calculation (it accounts for 60 percent of the transport fuel growth 1974-1979 even though in 1974 it accounted for only 35 percent of the fuel) and because:

a. a constant share was assumed, while in fact it probably increased; and

b. a relatively low fraction of diesel was assumed to be consumed (75 percent, while it may be as high as 80-85 percent) by the transport sector;

it is unlikely that revisions will reduce the 1974-1979 $\Delta E_T/\Delta$ GDP ratio relative to that for 1969-1973.

Table A-1. Growth of Gross National Product, 1965-1979

	GNP in billions of cruzeiros of 1970	Annual increase (percent)	Index of GNP (1970=100)
1965	143.9	--	69.1
1966	149.4	3.8	71.7
1967	156.6	4.8	75.2
1968	174.1	11.2	83.6
1969	191.4	10.0	91.9
1970	208.3	8.8	100.0
1971	236.0	13.3	113.3
1972	263.7	11.7	126.6
1973	300.4	14.0	144.2
1974	329.7	9.8	198.3
1975[p]	348.5	5.6	167.3
1976[p]	379.7	9.0	182.3
1977[p]	397.4	4.7	190.8
1978[p]	421.4	6.0	202.3
1979[p]	448.5	6.4	215.3

Note: p = preliminary data.

Source: Conjuntura Economica, vol. 34, no. 12, Dez. 1980.

Table A-2. Consumption of Diesel Oil by Sector and Sub-sector
Best Available Estimate, 1980

Sector	Fraction of total diesel consumption (percent)
Transport sector	71.3
- road transport	64.7
. urban passenger transport	8.4
. interurban passenger transport	7.1
. freight	49.2
- rail transport	3.9
- waterways	2.7
Agricultural sector	15.8
- tractors	13.0
- harvesters	0.8
- stationary motors	2.0
Industrial sector	10.8
Other sectors	2.1

Notes: 1. The difference in estimated consumption per tractor shows enormous variations between sources, that is, this sources estimates an annual consumption of 8,300 tractors prt tractor (which seems very high) for a fleet of about 288,000 tractors, which seems low. The Institute of Business Administration of the University of Sao Paulo assumed 1,500 liters per tractor for 380,000 tractors [25].

2. No sources estimate inter-urban consumption for road freight. Some estimate [3, 19] that of total road transport fuel consumption, 55 percent goes for intermunicipal uses of all kinds. Using this estimate as a basic, we get 28.5 percent of total diesel going for inter-urban and 20.7 percent for intra-urban cargo. This probably underestimates inter-urban freight.

Source: GEIPOT, "O custo do combustivel e a busca de novas saidas" - 1º Seminario Transporte Moderno Sobre Politica e Legislacao de Transporte, Sao Paulo, Novembro 1981.

Table A-3. Another Breakdown of Fuel Use by the Transport Sector

	Gasoline (ooo m^3)	Percent of total	Diesel (ooo m^3)	Percent of total	Fuel Oil (ooo m^3)	Percent of total	Other derivatives (ooo m^3)	Percent of total
Road	13,738.6	97.4	10,444.6	72.7	--	--	--	--
Rail	--	--	602.2	4.19	51.3	0.37	--	--
Water	3.1	--	733.5	5.11	1,508.0	10.96	0.3	--
Air	3.8	--	3.8	0.02	2.2	0.02	1,405.3	10.32
Total Transport	13,745.5	97.46	11,784.1	82.0	1,561.5	82.0	1,405.6	10.32

Source : GEIPOT - O Setor Transportes e o Modelo Energetico Brasileiro, 1980.

Table A-4. Another Breakdown of Consumption of Major Derivatives by Sector in the Brazilian Energy Model

Fuel oil	
	88 percent consumed in industry
	12 percent other (unspecified)
Gasoline	
	essentially all for individual transport and light cargo over short and medium distances (no further breakdown)
Diesel oil	
	75 percent consumed for road transport, of this:
	55 percent intermunicipal transport (primarily cargo)
	45 percent intramunicipal transport (primarily passengers)
	13 percent consumed by industry, mostly for electricity generation
	12 percent other (unspecified)

Source: Empresa Brasileira de Planejamiento de Transportes-GEIPOT, Plano Operacional de Transportes-Fase II, vol. 1 (Brasilia, Ministrerio dos Transportes, 1980).

Another breakdown of diesel consumption, from an earlier version of the energy model, is:

8.9 percent - industry
4.4 percent - primary sector
2.0 percent - electricity generation
76.1 percent - road transport, of which
55 percent intermunicipal transport
45 percent intramunicipal transport
3.5 percent - rail transport
3.9 percent - water transport
1.2 percent - other

Source: Comite do Balanco Energetico Nacional. Balanco Energetico Nacional (Brasilia, Ministerios das Minas e Energia, 1980).

Table A-5. One Estimated Breakdown of Gasoline and Diesel Consumption Institute of Business Administration

Gasoline	
	74.5 percent cars and pick-ups
	23.7 percent light trucks and utility vehicles
	1.7 percent stationary motors
Diesel	
	73.8 percent trucks
	11.4 percent buses
	8.5 percent tractors
	4.0 percent railways
	1.1 percent ships
	1.2 percent stationary motors

Source: IBA

Table A-6. Evolution of Fuels Used Primarily in Transport Sector in Terms of Equivalent Energy

	Anhydrous alcohol (1000 m^3)	Hydrated alcohol (1000 m^3)	Diesel (1000 m^3)	Gasoline/auto (1000 m^3)	Alcohol (1000 TPE)		Diesel (1000 TPE)	Gasoline (1000 TPE)	Total (1000 TPE)
1969	32	--	5,932	8,747	(27)	24	4,953	6,598	11,575
1970	184	--	6,515	9,705	(155)	139	5,440	7,318	12,897
1971	254	--	7,158	10,617	(213)	192	5,977	8,005	14,174
1972	391	--	8,178	12,004	(328)	295	6,829	4,051	16,175
1973	309	--	9,712	13,929	(260)	233	8,110	10,502	18,845
1974	190	--	10,749	14,322	(160)	143	8,975	10,799	19,917
1975	162	--	11,986	14,619	(136)	122	10,008	11,023	21,153
1976	172	--	13,797	14,724	(144)	130	11,520	11,102	22,752
1977	639	--	14,807	14,105	(537)	482	12,364	10,634	23,480
1978	1,506	2	16,164	15,246	(1,266)	1,137	13,497	11,495	26,129
1979	2,219	16	17,600	15,646	(1,876)	1,685	14,696	11,797	28,178

Notes: Automotive gasoline assumed to have a density of 734 kg/m^3, and a heating vale per ton 1.028 times crude oil. Thus 1 m^3 equals 0.754 TPE. Diesel assumed to have a density of 828 kg/m^3 and a heating valve per ton of 10,900 Meal or 1.009 times crude oil. Thus 1 m^3 equals 0.835 TPE. Alcohol assumed by source that:

1 m^3 anhydrous equals 0.840 TPE
1 m^3 hydrated equals 0.730 TPE.

Unfortunately, the source calculated incorrectly. If, as the source assumes, 1 m^3 of anhydrous alcohol mixed with gasoline replaces 1 m^3 of gasoline, then it is the equivalent of gasoline, which means 1 m^3 equals 0.754 TPE, not 0.840 TPE. Similarly, hydrated alcohol (which the source assumes requires 1.15 m^3 to replace 1 m^3 of gasoline) would be reduced to 0.656 TPE. However, with hydrated alcohol there is a conceptual issue, for we are developing a new motor for its use. In this case it seems reasonable to treat alcohol just as we treat gasoline and diesel--that is, the thermal content of the fuel (the source does not credit diesel with its higher efficiency of use in diesel motors). In this case 1 m^3 alcohol equals 0.468 TPE. The same could be said for anhydrous alcohol mixed with gasoline. The author has chosen not to because it seemed more useful here to follow the evolution of consumption of the standard Otto cycle fleet's consumption outside of the special conservation effort of mining alcohol. The figures are those given in the original source.

Source: Comite do Balanco Energetico Nacional, Balanco Energetico Nacional (Brasilia, Ministerio das Minas e Energia, 1980).

Appendix B

CHANGE IN FUEL EFFICIENCY OF NEW CARS IN BRAZIL 1973-1978

Improvement in Technical Efficiency of Car Fleet

A crucial factor of Brazil's energy conservation planning is improved fuel efficiency of the automotive fleet. How has this behaved since the OPEC price increases and how does the government intend to influence it in the future? Rather surprisingly, given the importance of the automotive fleet in Brazil's transportation fuel consumption pattern, the author has been unable to find any published estimates of fuel economy or, as a consequence, any goals regarding changing it. There is also little in the way of discussion of policy issues which are directly relevant to improved efficiency. For example, it is broadly (and probably correctly) assumed that price and tax policy has reduced gasoline consumption by automobiles; but the author has yet to see any quantitative attempt to measure how much or analyze why.

A brief analysis has been carried out in this appendix to try to partially fill this vacuum. The results are incomplete and the fuel consumption parameters are probably not definitive. However, they do strongly suggest that the Brazilian automotive fleet is becoming more fuel efficient. Table B-1 is based on estimates for 14 of the major makes (or series) of car and multiple use "camioneta"[12] produced in Brazil. These lines constituted about 75-80 percent of the total vehicles produced in those classes in 1973 and about 90 percent in 1978. The choice was made on the basis of availability of fuel consumption

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12. Multiple use "camionetas" range from hatchbacks such as the VW Brasilia or Fiat 147, that is essentially a car, to vans such as the VW Kombi. The former type is dominant.

estimates in the Transporte Moderna operating cost series.[13] No attempt was made to measure the fleet average. What is estimated is the change in average fuel consumption of new cars produced each year. No attempt was made to estimate improved efficiency of individual makes over time--1980 estimates were used for both 1973 and 1978. The focus is the result solely of change in fleet mix.

With this set of vehicles, there is a modest trend of 1.5 percent per year of improvement. This is a relatively small effect to detect over a 5-year period, especially given the fuel consumption estimates' possible variance. However:

a. The Transporte Moderno series is at least standardized to some extent. The ratio between car types has a higher confidence than the absolute numbers. It is the ratio which mostly concerns us here.

b. Other factors indicate that the direction is right, and that indeed 1.5 percent per year is probably an underestimate of the rate of improvement.

   1. Higher fuel consuming versions of particular makes have declined; for example, the six cylinder version of the Opala (see table B-1).

   2. Makes which have declined in their market share tend to be more fuel consuming, while those that have increased tend to be less fuel consuming. The cars surveyed constituted 90 percent of the fleet in 1978 but only 80 percent in 1973. Those excluded tend to be more fuel consuming vehicles.

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13. See [20, 21, 22]. The 1980 estimates are generally lower than in previous years, and have been used. VW 1500 estimate for 1975 in [20] is recalculated on basis of having same relation to VW 1300 figure in [22] (1980).

Table B-1. Change in Fuel Efficiency Mix of New Cars Produced in Brazil between 1973 and 1978

Make or series	Cars produced in year (ooo)		Average fuel consumption[a]	Fuel consumed to move all cars produced 1 km (1000 liters)	
	1973	1978	(liter per km)	1973	1978
VW 1300 series	95.3	162.5	.0881	8.4	14.3
VW 1500	122.1	--	.0921	11.2	--
Brasilia series[b]	34.7	159.2	.0864	3.0	13.8
Passat series[b]	--	89.6	.096	--	8.6
Kombi series[b]	40.8	45.5	.143	5.8	6.5
Fiat 147L[b]	--	88.9	.0713	--	6.3

Appendix C

BRIEF DISCUSSION OF THREE EFFICIENCY-IMPROVING ACTIONS FOR ROAD FREIGHT

Measure	Energy saving when carried out	Comments
1. Turbocharge diesel engines	5-13%	Installation raises the cost of a heavy truck (40-45 tons gross weight) by 10 percent, but greater power allows same trip to be made in 70-80 percent of time, with impact on overall costs as shown in table C-1 [23]. Application may be limited economically to heavy truck fleet. Intercity buses, which tend to have higher power-to-weight ratio, may not benefit and evidence on fuel saving is mixed [23]. Urban buses tend to be underpowered and may benefit. Driver must be trained to take advantage of turbocharging. Firm must be able to take advantage of shorter trip time by using truck for more trips or investment does not pay. Although a truck with turbocharger requires more investment, higher roadspeed means investment per vehicle-kilometer per month is reduced. In the case in reference 23, the investment per vehicle-km/month fell from 65 to 60 cruzeiras (April 1976). No estimates available of extent to which turbocharging has been adopted.

Measure	Energy saving when carried out	Comments
2. Proper setting of fuel injector	13-30%	Many drivers change the setting of their fuel injectors in order to increase the power of the motor. A characteristic symptom of this changed setting is excessive smoke emissions. In 1970 it was estimated that 57 percent of diesel vehicles on the Rio-São Paulo road were emitting excess smoke and had probably had their fuel injector setting changed [24]. The maximum increase in power is on the order of 6-8 percent [24]. The lower increase in fuel consumption associated with resetting cited here (13 percent) is for a dynamometer test using an OM-352 Mercedes Benz engine where the engine was reset to deliver 6 percent more power. The higher figure is for a road test with an MB L-1113, using the same engine [24]. It is not clear to what extent this once common practice has continued. Higher diesel prices should have done much to discourage it.
3. Carry empty trucks on other empty trucks during return journeys	20-25%	Many trucks are unable to find loads for their return journey, and since the majority are flatbed the possibility exists for various combinations where one truck carries another. Measurements with an optimized system for heavy trucks showed a fuel saving for the round trip of 23 percent and overall operating cost savings of 16 percent in 1976 [15]. Unfortunately, the condi- (which required a coordinated team of four truck-trailers, where on the return one would carry two tractors and the other the two trailers) are highly atypical.

Measure	Energy saving when carried out	Comments
		The system in less sophisticated form appears to be happening with increasing frequency on long runs between the northeast and southeast.

Table C-1. Impact on Operating Costs of a Heavy Truck (40 E Gross) of Turbocharging

	Scania L-110 standard (8000 km/month)	3-axle trailer turbocharged (9600 km/month)
Fixed costs		
Depreciation and return to capital	10,540	11,622
Driver's salary	5,247	5,247
License and insurance	3,710	4,031
Subtotal per month	19,497	20,900
Variable costs		
Tires (per km)	0.968	1.053
Fuel (per km)	0.960	0.866
Other maintenance costs (per km)	0.909	0.954
Subtotal per kilometer	2,837	2,873
Subtotal per month	22,696	27,581
Total fixed and variable costs per month	42,193	48,481
Total fixed and variable costs per kilometer	5.27	5.05

Source: "Turbocompressor Economiza Combustivel," Transporte Moderno (Maio 1976), pp. 26-30.

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