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The Brazilian Energy Policy and the Alcohol Program

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Chapter 1: Introduction

The so-called "energy problem" in the Brazilian economy is basically a problem with the country's external accounts, that is, the crisis in the balance of payments caused by two major oil price increases, in 1973-74 and in 1979-80. In 1972 Brazil's oil imports corresponded to 11.1 percent of the country's total imports and 11.8 percent of total exports. In 1974, on the other hand, those same proportions had increased to 22.5 and 35.7 percent, respectively. Before the second oil "shock" a peak in those proportions was reached in 1976: 31.1 and 38.0 percent, respectively. However, with the second major increase in oil prices during 1979-80 things again deteriorated: in 1980 Brazil's total oil imports corresponded to 41.0 percent of total imports and 46.7 percent of total exports.

Another way of looking at the same problem is to examine the composition of total consumption of primary energy in Brazil.[1] In 1973, for a total consumption of 88,415 tons of oil equivalent, the distribution was the following: oil, 42.8 percent; wood, 27.0 percent; hydraulic, 19.0 percent; sugarcane, 8.0 percent; metallurgical coal, 2.1 percent; steam coal, 0.7 percent; natural gas, 0.3 percent; and other, 0.1 percent. In that same year, Brazil imported 40.3 percent of its total energy requirements, but these imports were highly concentrated in petroleum, with 96.3 percent of the total. In 1982, with a total energy consumption of 145,809 thousand tons of oil equivalent, the composition was the following: oil, 35.7 percent; hydraulic, 28.1 percent; wood, 19.8 percent; sugarcane, 10.2 percent; metallurgical coal, 2.6 percent; steam coal, 1.5 percent; natural gas, 1.0 percent; uranium, 0.8 percent; and other, 0.3 percent. Also in 1982, imports had declined to 29.5 of total consumption but still were highly concentrated in oil, with 92.5 percent.

These figures indicate that some changes had already occurred in the Brazilian energy matrix by 1982, including a lower dependence on oil imports. Oil exploration was increased after 1974 and the alcohol program dates back to 1975. In addition, just after the beginning of the second oil shock Brazil decided to implement an ambitious program of oil substitution with targets through 1985, involving a larger alcohol production goal, the beginning of a program to increase production of mineral coal (170 thousand barrels of oil equivalent), and the first attempts to introduce official plans for substituting vegetable oils for diesel oil and establishing energy forests, producing wood and charcoal, to substitute for fuel oil. Not all of these plans were implemented, however (vegetable oils and energy forests have not been pursued), and at least one of them had its goal for 1985 considerably reduced (mineral coal). On the other hand, domestic production of oil and alcohol performed quite well.

What seems more important, however, is that such new programs were announced and some of them implemented without the provision of clear evidence of economic feasibility. Certainly, the final objective after the two oil price increases, and even today, was/is the substitution of oil imports with

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[1] Data from Brasil-Ministerio das Minas e Energia, Balanco Energetico Nacional. Brasilia, 1983.

domestic energy sources. However, the country needed to identify, among the possible alternatives to oil products, those technically as well as economically feasible. Only with such a procedure would Brazil realize the maximum possible savings of foreign exchange. The alcohol program, created in 1975 primarily to increase the production of anhydrous alcohol but after 1979 also the use of hydrated alcohol, is a good example of the government's disregard for economic considerations. We hope to provide evidence of that in this paper.

Such a program, it must be said, has attracted a great deal of domestic and international interest as well as a good degree of controversy. The country has a long tradition in sugar production, and also has the technology for alcohol production, including a fairly well developed capital goods industry. In July 1979, the Brazilian energy program set a target of 10.7 billion liters of alcohol (about 150 thousand barrels of gasoline equivalent) to be produced in the crop year 1985-86, and started to provide the incentives, mainly subsidized credit to producers, to stimulate the participation of the private sector, as well as several advantages to consumers. At the 1985 prices of gasoline, that production would save the country the expenditure of US$ 1.5 billion in imports. In May 1980, about 60 percent of that target had been reached in terms of projects approved by the government, and in the crop year 1984/85, 85 percent of the target was actually produced. Although alcohol production is only one part of the Brazilian energy program, which also includes coal, domestic oil and a few others, it was the most important in terms of the implementation of agro-industrial projects until 1982. Total contemplated investment through 1985 is estimated to be above US$ 8 billion, and such an amount is not to be neglected nowadays in the critical situation faced by the Brazilian economy.

In this paper we will address the controversy regarding the alcohol program as a major part of Brazil's policy of substituting for oil products. First, we will cover some antecedents of the program as well as the incentives provided by the Brazilian government. Second, we will discuss its economic controversy, mainly with respect to the social costs of producing alcohol and substituting for gasoline, as compared to other domestic sources substituting for oil products in general. Finally, we will give some attention to equity considerations related to three aspects: possible impacts on food production, employment generation, and the distribution of benefits from the use of alcohol. Our conclusions are that the country would gain more in terms of foreign exchange savings from an energy program placing more emphasis on other alternatives to oil products rather than alcohol because of the latter's extremely high social cost of production. We also conclude that on equity grounds the alcohol program is not a good choice, due to the negative impacts on domestic food production, increased seasonality of employment, and the concentration of benefits to middle and high income families.

Chapter 2: The Alcohol Program and its Incentives

The first sign of using the agricultural sector as a partial solution to the energy crisis was given in November 1975 with the creation of PROALCOOL - National Alcohol Program. This federally supported program had the objective of increasing sugarcane production, and eventually other crops, as well as the industrial capacity for transforming the raw material into alcohol for the substitution of gasohol for gasoline. The program's first target was to produce about 3.0 billion liters of alcohol in 1980 (as compared to the realized production of 625 million liters in the crop year 1974-75). This is usually recognized as phase one of the alcohol program, as compared with phase two, the present one, which started in July 1979 at the beginning of the second major oil price increase.

It is clear that one of the reasons for such a program was the substantial oil price increase occurring after September 1973. The response of the sugar-alcohol sector was very prompt, and between 1975 and 1979 the area cultivated with sugarcane in Brazil increased by close to 750 thousand hectares (29 percent). Supporting that reaction was the drastic fall in international sugar prices after 1974. Most of the increased alcohol industrial capacity in this first phase was from annexed distilleries, integrated with the operations of the main sugar plants. In sugar year 1978-79, total alcohol production was 2.4 billion liters and in 1979-80 it had surpassed the target of 3.0 billion liters, being 2.7 billion liters (38,000 barrels of oil equivalent) of anhydrous alcohol and 700 million liters (9,600 barrels equivalent) of hydrated alcohol. Most of this production (anhydrous alcohol) was used for gasohol in a 20% mixture during 1979-80. The smaller portion, hydrated alcohol, was used in the chemical sector and as fuel for adapted engines and new automobiles. The emphasis, however, on new alcohol automobiles was clearer with phase two of the program, the one starting in July 1979, with the goal of producing 10.7 billion liters (about 150,000 barrels equivalent) of hydrated alcohol in the crop year 1985-86 (June to May). In crop year 1984-85, 45 percent of this target had been reached, which was facilitated by a lower sugar production caused by declining international prices.

The main instrument used to stimulate investment in new capacity during phase one was subsidized credit. The beneficiaries were agricultural producers, cooperatives, and the distilleries, including those with sugarcane production.

The basic conditions of financing in PROALCOOL during 1975-79 (phase one) were[2]: for agricultural purposes, 100 percent of financing, an interest rate of 13-15 percent, and repayment periods of from one year (circulating capital) to twelve years (fixed investments). For industrial purposes: 80-90 percent of financing, depending on the regions, 15-17 percent interest, and 3-12 years for repayment. The annual inflation rates in Brazil from 1975 to 1979 were, respectively: 28, 41, 43, 39, and 54 percent, which indicate the existence of quite heavy subsidies to producers.

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[2]See Homem de Melo, F. and E.G. Fonseca, Proalcool, Energia e Transportes Sao Paulo, Editora Pioneira, 1981, p. 12.

With respect to other credit operations in agriculture, it should be noted that the conditions for alcohol projects were similar to those prevailing in the regular rural credit programs, including those for investment, with two exceptions. The exceptions were the financing of a larger part of the required capital, and a lower interest rate on larger loans (15 percent yearly). However, the ease with which such funds could be obtained by those interested in the alcohol program was in contrast with the difficulties and uncertainties of obtaining funds for other rural projects, due to the management of the period's anti-inflation policies, a point which will be stressed below. It is no surprise that the alcohol program with such highly favorable credit conditions received strong support from sugarcane and alcohol producers, as well as from manufacturers of distilleries. In that first phase, however, the automobile industry was not a strong supporter, the likely reason being the concentration of the program on anhydrous alcohol (gasohol) and a distrust of the program's feasibility over the medium and long terms.

Some people have argued that, even with such progress in alcohol production, Brazil was too slow in reacting to the oil crisis. Three reasons might be mentioned to justify the behavior of the government. First, between January 1974 and early 1979, nominal prices of imported oil remained approximately constant, at the same time that consumer prices in the United States went up by 50 percent. As a result, real oil prices experienced a significant decline (in 1970 dollars, from US$ 9.77 per barrel in 1974 to US$ 7.34 in 1978). Second, Brazilian exports during 1974-78 performed reasonably well. Total exports increased every year and their purchasing power in 1978 was 45 percent above that of 1974, and even 21 percent above 1973, before the oil crisis. Finally, with the oil prices prevailing during 1974-78, most of the alternatives to oil products available in Brazil were far from being economically feasible. This last point will be analyzed later in the paper.

After the second oil shock, however, which started in June, 1979 and during which oil prices increased to US$ 18 per barrel, Brazil took other measures in the energy area. These included a second phase of the alcohol program as well as an official plan to increase mineral coal production (170,000 barrels equivalent-day in 1985). The so-called "basic project" of the Brazilian energy policy, made public in July 1979, had the target of reaching an alcohol production of 10.7 billion liters in 1985 (about 150,000 barrels equivalent-day). Later on, after another increase in the price of imported oil, in December 1979 the minister of Industry and Commerce announced a new, although unofficial, objective of 14.0 billion liters for 1987. Conservatively assuming a 25 percent increase in volumetric consumption by alcohol (hydrated) vehicles compared to gasoline vehicles (a factor of equivalence),[3]

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[3]This is the increase in volumetric consumption needed to obtain the same mileage. We use the word "conservatively" since the results of consumption tests have been in the range 26.4 - 28.4 percent increased consumption.

The 1985 target corresponds to 147,000 barrels equivalent-day. According to Brazil's energy program published in 1981, alcohol production in 1985 would correspond to about 10 percent[4] of total 1985 requirements in terms of oil plus oil substitutes. The economic recession in Brazil during 1981-84 caused a decline in total 1985 requirements, which in 1981 was predicted to be 1,700 million barrels of oil equivalent-day.

Finally, two other biomass-related programs were created, although not implemented, by the Brazilian government in 1980. The timing was quite close to the start of the Iraq-Iran conflict late in the year and the unfulfilled threat of chaos in the international oil market. The first program was the PROOLEO (National Program of Vegetable Oils), with the objective of substituting for 16 percent of diesel oil in 1985 (about 65,000 barrels equivalent/day), and second was the program for energy forests, with wood and charcoal (120,000 barrels equivalent/day) substituting for 24 percent of the fuel oil consumption predicted for 1985. The contemplated new acreage was 1,831 thousand hectares to be planted with forests in 1985 and an investment of US$ 210 millions, in addition to the use of natural forests. Both programs, however, never had a supporting institutional framework as did the alcohol program, and no financial resources were ever allocated to them. One of the main reasons for this is the fact that by the end of 1980 the Brazilian government started to pursue restrictive fiscal and monetary policies because of the critical situation with regard to the balance of payments. However, on the consumption side the use of wood/charcoal has been stimulated by the interruption of supplies of fuel oil to several industries (sawmills, grain drying, wood, and ceramics), introduced by the National Petroleum Council in August 1980.

The main policy instrument used to provide incentives during phase two of the alcohol program continued to be subsidized credit to producers. In the industrial sector, financing was available for up to 80 percent of the fixed investment; and in the agricultural sector, financing for 100 percent of requirements, respecting the limits of 80 and 60 percent of the value of expected production in North/Northeast regions and other regions, respectively. The nominal interest rates in 1980 were the following: 22-26 percent in the industrial sector and 10-24 percent in agriculture's circulating capital (the higher figures being valid for Brazil's center-south region), and 15-29 percent for agriculture's investment capital. For reference, inflation in Brazil during 1980 was 100 percent. In 1981 interest rates for the acquisition of distilleries were increased to 55 percent in the center-south, and in 1982 to 70 percent of the rate of monetary correction (an indexation system), which is supposed to run close to inflation, plus 5 percent. Presently, with practically no money available from official

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[4]In the official version of the Brazilian energy program, alcohol production in 1985 is 170,000 barrels equivalent-day with the following distribution and factors of equivalence: (a) hydrated alcohol, 53.5 percent (1.15 or 15 percent more volumetric consumption); (b) anhydrous alcohol, 31.3 percent (zero, or perfect equivalence with gasoline; c) chemical sector, 15.1 percent (zero, perfect equivalence). In our calculation we assumed alcohol to be used entirely in vehicles (hydrated and anhydrous) with a factor of equivalence of 1.25 (25 percent more volumetric consumption).

sources, the interest rate is 100 percent of monetary correction plus 5 percent; that is, a real rate has been finally introduced in financing alcohol projects, although lower than market rates. At the present time, market rates of interest in Brazil are in the range 35-40 percent real, that is, after adjustment for inflation (monetary correction).

The golden years of the alcohol program in Brazil were 1979, 1980 and 1981. Such a conclusion is based on the following reasoning. The average rates of inflation in the country were 54 percent in 1979, 100 percent in 1980 and 110 percent in 1981. From then on, Brazil had the following inflation rates: 95 percent in 1982, 155 percent in 1983, and, finally, 221 percent in 1984. If we consider an alcohol distillery obtaining credit in 1980, with the conditions just described, that is, financing at 22-26 nominal interest rate for 80 percent of the capital requirements, the final weighted interest rate (opportunity cost of capital) was about -33 percent, which means a substantial subsidy for capital.[5] In the next section we will show how such a heavy capital subsidy is crucial to make it possible to presently sell alcohol at the distilleries' gates in the range of US$ 50-60 per barrel equivalent. It must be noted, however, that at the same time financial resources were easily available for alcohol projects, total real credit available to agriculture declined 29 percent between 1979 and 1982.

On the other hand, beginning in 1979 consumers of alcohol were benefitted by a favorable relation of alcohol prices to gasoline prices (range of 0.41-0.53 from September 1979 to April 1981), as well as by being able to purchase the fuel on Saturdays, contrary to the situation faced by gasoline consumers. Also, it is useful to mention that when moving from a program based on anhydrous alcohol (gasohol) to hydrated alcohol, consumers were offered the alternatives of either buying a new alcohol vehicle or having an adapted or transformed one. In 1979, only 4,624 alcohol vehicles were produced in Brazil, but just one year later, in 1980, total sales reached 254,000 units, basically a result of a shift in consumers' demand for fuel due to the favorable relative price of alcohol compared to gasoline.

However, what seemed to be running quite nicely in terms of consumer acceptance was drastically inverted during 1981. Total sales reached only 129,000 units, which was a serious threat to the fulfillment of the protocol signed by the Brazilian government and the automobile industry, which called for the production of 900,000 alcohol vehicles during the period 1980-82.[6] The existence of such an agreement is also an indication that the automobile industry started to effectively support the alcohol program in phase two, contrary to what happened in phase one. There was the additional problem of even more drastically falling sales over the second semester of 1981 and the first months of 1982. In several months of that critical period only about three to four thousand vehicles were sold by the industry to consumers.

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[5]This is the result of financing 80 percent at a 25 percent rate of interest, inflation of 100 percent, and an opportunity cost of capital (for the remaining 20 percent) at a real rate of 15 percent (115 percent nominal).

[6]Parallel to the protocol with the automobile industry, there was an agreement with workshops converting engines from gasoline to alcohol, for 270,000 units during 1980-82.

Two main reasons were mentioned in the press at that time to explain the sudden change in consumers' preferences. The first was a widespread feeling that the government did not have a firm commitment in terms of the program's future. That would be explained by the beginning of difficulties in obtaining official financing for new distilleries, as well as increased interest rates. In addition, the price ratio of alcohol to gasoline was increased at certain times (it ranged from 0.61-0.64 during May 1981 to May 1982). The second reason was the growing complaints by consumers, particularly the taxi drivers, about the low quality[7] and high volumetric consumption of alcohol vehicles compared to gasoline ones.

The situation was so serious early in 1982 that a projection of the sales of alcohol vehicles from the first three months[8] suggested the real possibility of selling no more than 40,000-50,000 units in the entire year. As a result of that situation, and responding to the pressures coming from interested parties such as planters, owners of distilleries, producers of equipment, the automobile industry, and retailers, the government in April 1982 approved the so-called package of incentives for alcohol vehicles. Four basic measures were taken jointly by the government and the automobile industry: (a) a final price for alcohol vehicles two percent lower than the price for gasoline vehicles, together with a guarantee on the former for 20,000 kilometers and free engine adjustments during the first 180 days; (b) a decrease of six percentage points in the value added tax for alcohol vehicles (from 33 to 27 percent) as compared to gasoline models; (c) a price ratio (alcohol to gasoline) to consumers not above 0.65, that is, alcohol would cost no more than 65 percent of the retail price of gasoline per liter (actually, the proportion was maintained roughly at 0.58 until about mid-1984, when it was increased to 0.64); and (d) a lower annual licensing tax for alcohol as compared to gasoline vehicles.[9]

In fact, sales of alcohol automobiles did increase after these measures were taken, and 1982 closed with a total of 238,000 units sold. In addition, 592,000 units were sold in 1983, and 561,000 in 1984. At the same time, the number of converted engines (engines converted from gasoline to alcohol in used automobiles) continued to decline and today have no significance. Also, the proportion of alcohol vehicles in total sales increased over the years, although in some of the years the economic recession caused a decline in total sales (nowadays, 80-90 percent of the industry's domestic sales are alcohol vehicles).

A few reasons can be given for the recovery in sales of alcohol automobiles that started in mid-1982. First, the incentives themselves as just described. Second, beginning in September 1982 with the crisis in

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[7]The president of the National Petroleum Council, an official institution, was one among many with such a complaint. See O Estado de Sao Paulo, March 19, 1982, p. 29.

[8]In January 1982, 3,886 units and in February of the same year, 3,755 units were sold. See O Estado de Sao Paulo, March 6, 1982, p. 28.

[9]After these measures were introduced, taxi drivers gained an additional advantage: they were able to buy alcohol vehicles with zero value added tax and special financing plans.

international financial markets initiated by Mexico's case, Brazil faced a severe crisis in its balance of payments, which culminated in the signing of an agreement for economic adjustment with the International Monetary Fund in February 1983. As a consequence, the threat of sharply lower oil imports and domestic rationing were factors favoring the substitution of alcohol for gasoline automobiles. Finally, all indications are that engine quality was improved over time after investments were made by the industry.

With respect to trucks, one of the important measures taken by the government, through the National Petroleum Council, was to require the use of alcohol trucks (Otto engines or adapted diesel to consume additivated alcohol -- alcohol plus a combustion starter) in distilleries, in place of the normal diesel trucks. That measure was introduced in April 1983 and required a 10 percent replacement in 1983, the percentage growing ten points each year until reaching 40 percent replacement in 1986. In 1987 the distilleries will be required to have no more diesel trucks in their fleets.

Chapter 3: Relevant Economic Aspects

Although the alcohol program was one of the most important parts of Brazil's energy policy after the first oil crisis in 1973-74, it is interesting to note that at no time were government officials concerned about providing information and evidence related to the economic feasibility of alcohol as a substitute for gasoline, and at the same time no economic comparisons were made with other available alternatives to oil products.[10] It is certain that the final objective of the alcohol program is the substitution of oil imports and the consequent decrease in the country's external vulnerability. However, what was needed then, and still is today, is more than simply identifying technically feasible alternatives to oil products. Such technically feasible solutions would be able to provide some savings in oil imports, but they would not necessarily guarantee the maximum possible savings.

The adequate economic treatment of such a problem would require a complete analysis of the energy matrix, that is, involve an economic analysis of all technically feasible alternatives to oil products. Among the guidelines for this analysis we would mention production costs per equivalent barrel and investments required, as well as the need for imported inputs. The first two, basically, might be combined in a social cost-benefit analysis. As a result of this analysis, the country should have the choice of a number of options, including oil products and a proper time horizon for the alternatives considered, and based on lower social costs, investments, and imported inputs. In other words, the ability to choose alternatives with higher social rates of return. There is no doubt that society prefers a higher level of product at lower costs than a lower level at higher costs. The Brazilian economic crisis, continuing from the mid-seventies to the present, is one additional reason for considering adequately the alternatives for investments in areas such as energy.

The available evidence about various alternatives to petroleum products will show that the Brazilian energy policy is not entirely approved by a test of social-economic feasibility. We were able to gather, from different sources, the following estimates,[11] all expressed in May 1981 dollars, and per equivalent barrels: (a) mineral coal: US$ 10-15; (b) charcoal: US$ 19-24; (c) shale oil: US$ 30-40; (d) coal gas: US$ 41-69; (e) domestic oil: US$ 15-20; (f) hydrated alcohol (substituting for gasoline): US$ 79-91; (g) hydrated alcohol (substituting for diesel oil, Otto engines): US$ 137-158;

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[10]See, for instance, Brasil-Ministerio das Minas e Energia, Modelo Energetico Brasileiro, Brasilia, May 1981.

[11]See Homem de Melo, F. and E.R. Pelin. Solucoes Energeticas e a Economia Brasileira. Editora Hucitec, Sao Paulo, Brazil, 1984, pp. 21-22. Homem de Melo, F., "Os Riscos das Solucoes Energeticas de Emergencia", Gazeta Mercantil, August 28, 1983, p. 84. The estimate for charcoal is from an independent research institution (Institute of Technological Research, Sao Paulo) and not from federal sources related to the program of energy forests.

(h) additivated alcohol (alcohol plus a combustion starter, substituting for diesel oil in diesel engines): US$ 148-170; (i) vegetable oils (substituting for diesel oil): US$ 84-140, depending on the crops used.[12] More recently, Brazil has discovered large reserves of natural gas in the coastal area as well as in the Amazon region.[13] Estimates from the World Bank for other countries indicate this fuel is competitive with oil in economic terms.[14]

With respect to costs of alcohol production in Brazil, we can provide more detailed evidence from our previous specific research. In Table 1, we present estimates of social production costs of hydrated alcohol and the resulting social internal rates of return for the state of Sao Paulo, the state with the largest production in Brazil and with the most efficient production methods. The analysis was always based on a social cost-benefit framework. That is, instead of using market prices, we used "social" prices[15] which, although not being observed by economic agents, reflect the opportunity costs for society as a whole. Corrections, as compared to market prices, were introduced for the exchange rate (a 30 percent decrease in May 1981 and 23 percent in January 1983, assuming overvaluation of the cruzeiro), for capital costs (a 15 percent social opportunity cost of capital as opposed to the subsidized financing), and for prices of inputs and of capital goods (excluding indirect taxes, export subsidies, and import tariffs). Labor was evaluated at market wages since the the latter have been consistently above the minimum wage in rural areas, and land was considered at the prevailing market rental rates. The next to the last line in Table 1 shows the social (internal) rate of return, that is, the discount rate that equates the present value of the project's benefits to the present value of its costs. Benefits are gasoline savings, valued at Rotterdam's price plus 10 percent (US$ 45.35 per barrel in May 1981).

In Table 1 we show three estimates. The first one is based on prices for May 1981, and the only change made to determine the second estimate is the use of nominal cruzeiro prices of inputs for January 1983. The third estimate in Table 1, with prices for January 1983, includes technical change and has four differences in relation to the first two estimates: (a) use of the by-product

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[12]A degree of caution should be used with some of the estimates. Since they come from different sources, there was no control over the methdology used. We were unable to obtain social costs of hydroelectricity in Brazil, although it is becoming important as a substitute for the use of fuel oil in industry. In addition, the World Bank reports a range of US$ 47.50-71.24 (January 1983 dollars) for the cost of synthetic fuels obtained from coal. See Pelin, E.R., "Avaliacao Economica do Alcool Hidratado Carburante no Curto e Medio Prazos", Doctoral dissertation, Department of Economics, University of Sao Paulo, 1983, p. 184.

[13]The estimated reserves correspond to 160,000 equivalent barrels-day, which is superior to the amount from the alcohol program. See Rodrigues, E.C., "Gases, do Metano aos Residuais," O Estado de Sao Paulo, 15 April, 1983, p.44.

[14]Specifically for methanol the World Bank estimates its cost from natural gas to be in the range US$ 29.69-53.43 (January 1983 dollars). See Pelin, E.R., "Avaliacao Economica...", op.cit., p. 184.

[15]Based on Contador, C.R., Avaliacao Social de Projetos, Editora Atlas, Sao Paulo, Brazil, 1981.

Table 1: Social Production Costs of Hydrated Alcohol, State of Sao Paulo, In Cruzeiros and Dollars per Equivalent Barrel*

Categories of Costs	May 1981	January 1983	January 1983 (With technical change)
1. Agricultural:	25.67	68.39	62.60
Operational:	18.10	42.39	38.99
o Variable	14.59	30.09	29.22
o Fixed	3.51	11.50	9.77
Land:	2.11	5.90	5.52
Capital:	5.46	20.10	18.09
2. Industrial:	20.32	57.44	50.19
Operational:	10.04	29.32	26.48
o Variable	3.30	10.86	11.09
o Fixed	6.74	18.46	15.39
Capital:	10.28	28.12	23.71
3. Total:**			
Cr$/l	45.99	125.83	105.66
US$/Barrel-equivalent	84.04	79.42	66.70
4. Social Rate Return	-10.04	-12.50	-5.75
5. Alcohol Costs/ Gasoline Prices	2.04	2.30	-

Sources: Homem de Melo, F. and E. R. Pelin, Solucoes Energeticas..., op.cit., 1984, p. 130; E. R. Pelin, "Avaliacao Economica do Alcool Hidratado Carburante no Curto e Medio Prazos." Doctoral dissertation, Department of Economics, University of Sao Paulo, 1983, p. 88 and P. 155.

* In May 1981, an equivalent barrel corresponded to 198.75 liters; in January 1983 to 204.16, based on consumption tests of vehicles produced.

** Taking into account credit from selling by-products.

bagasse as pellets and selling it as substitute for fuel oil, or to generate steam for electricity and also selling it; b) extension of the harvesting period from an effective 140 days to 176 days (April to November); (c) an increase in average agricultural yields for the state of Sao Paulo, to a level of 85.3 t/ha in 1990 (11 percent increase); (d) an increase in the sugar grade of the input sugarcane from 14 to 14.7 percent. The resulting costs should then be interpreted as possibly occurring in a number of years and in a gradual way rather than instantaneously in 1983.

It is important to observe in Table 1 that all three estimates present highly negative social rates of return. For a reference, prices for a barrel of refined gasoline in Rotterdam were US$ 41.23 in May 1981 and US$ 34.55 in January 1983. Late in 1984 gasoline prices had declined to US$ 27-29 per barrel. The observed decline in the social cost of producing alcohol from May 1981 to January 1983 (columns one and two in Table 1) was mostly due to declines in relative prices of fertilizers/chemicals, labor and capital goods, caused by the Brazilian economic recession during that period and a less intense implementation of the program, both factors contributing to a decreased demand. At the same time, however, gasoline prices declined and the ratio of alcohol costs to gasoline prices actually increased, as can be seen in the bottom line in Table 1.

The final costs and related rates of return for alcohol production in Brazil are extremely unfavorable to its existence as an important component of the energy policy in the country. Using the estimates listed earlier for other alternatives, we can conclude that, at least in part, Brazil's energy policy is today wrongly oriented. Production targets established in 1979 for mineral coal and shale oil through 1985 have been drastically cut. We should place more emphasis on mineral coal, charcoal, domestic oil, natural gas, and shale oil, and much less emphasis on alcohol. Mention should also be made of increased conservation, including improved processes, mass transportation, and long-distance transportation as interesting alternatives.

One question, however, remains to be answered. During the four months of June-September 1981 the average price received[16] by alcohol producers in Sao Paulo was US$ 63.9 per equivalent-barrel. During 1984 and early 1985 such prices received were even lower, staying in the range US$ 50-60 per equivalent barrel. In real terms, prices received by alcohol producers in Sao Paulo declined 16 percent when comparing 1984 and 1981. Although Table 1 will not provide a complete answer to this apparently inconsistent situation -- that is, social production costs close to US$ 80 per equivalent barrel and prices received at a much lower level -- it goes quite far in that direction. The answer is found in the critical importance of capital costs (opportunity costs) in total alcohol costs. In May 1981 capital (agriculture plus industry) represented 34.2 percent of total alcohol cost, and in January 1983 its share was 38.3 percent (Table 1). In dollar terms, this share corresponded to US$ 28.43 in May 1981 and to US$ 30.44 per equivalent barrel

[16]Alcohol prices to producers are entirely administered by the federal government; Petrobras, the state oil company is the sole buyer.

in January 1983. If we subtract these amounts from the total costs in Table 1, we obtain respectively the much lower figures of US$ 55.61 and US$ 48.98. In other words, excepting the opportunity cost of capital (15 percent in Table 1),[17] alcohol costs become much lower. Excepting capital costs in Table 1 means working with a zero opportunity cost. Earlier in this paper we concluded that private agents in 1980 worked with a weighted interest rate of -33 percent in the industrial part of an alcohol project. This highly negative interest rate helps to explain why private costs of alcohol production in Brazil are considerably below social (opportunity) costs, and below the lower levels of prices received by alcohol producers mentioned earlier. This explanation shows that alcohol producers received a substantial transfer of capital from society as a whole for many years in such a way that later, when the government decreased prices to them in real terms, no major problem occurred.[18]

Now, to be more confident in the results shown in Table 1, we should search for parallel evidence. One of the most interesting and reliable is that published in January 1985 by three researchers from the official federal research institution IPEA -- Instituto de Planejamento Economico e Social -- of the Planning Ministry. To IPEA, "social cost" (shadow prices) of producing alcohol was the sum of direct production costs and land opportunity costs. Let us quote from them[19]: "The direct production costs are composed of sugarcane's agricultural production cost, the cost of implementing and operating the alcohol distilleries, and the cost of transporting alcohol to consumption centers. The opportunity costs are those caused by using land for sugarcane and consequently displacing other crops, which can bring an increase in production and transport costs of crops for the internal market, as well as the reduction in international competitiveness of exportables." When mentioning the results obtained with a dynamic linear programming model, their words are that "the estimated value for the marginal cost of alcohol corresponds approximately to US$ 89 per barrel equivalent of oil"[20] in 1984 dollars. Even allowing for a different methodology used in the estimation, this result is in the neighborhood of those listed in Table 1.

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[17]Contador, C.R.. Avaliacao Social..., op.cit., gives the range 15-18 percent for the opportunity cost of capital in Brazil and we used the lower limit. In addition, da Motta, R.S., "Shadow Prices for Brazil" (Abstract), University College, London, estimated the opportunity cost of capital in the range 17.0-17.9 percent. As a result, if anything, we are underestimating capital costs in the analysis.

[18]During 1977-81 real prices to alcohol producers increased almost yearly. In 1981 the level was 12 percent higher than in 1977. The contrary occurred during 1981-84. In 1984 the real alcohol price was 16 percent below the 1981 price and 7 percent below that for 1977. It should also be mentioned that in 1984 the federal government authorized Petrobras to buy alcohol from all distilleries in a period of seven months compared to the previous twelve months period. This relieved the distilleries from costs of carrying stocks and consequently reduced their private (as against social) costs.

[19]Tourinho, O.A.F. et al., Agricultura e Producao de Energia: Um Modelo de Programacao Linear para Avaliacao Economica do Proalcool. IPEA, Ministry of Planning, Brazil, January 1985.

[20]Tourinho, O.A.F. et al., op.cit., p. 69.

In addition to this recent estimate, we can mention in less detail the following ones, always using an assessment that tries to eliminate credit subsidies and all in dollars of May 1981: (a) Borges,[21] with data from Copersucar's distilleries in Sao Paulo, US$ 82.20 per barrel equivalent (12 percent opportunity cost for all capital, with no correction for the exchange rate); (b) Williamson,[22] US$ 94.40 per barrel equivalent (12 percent opportunity cost for all capital); (c) Instituto de Pesquisas Tecnologicas,[23] US$ 83.30 per barrel equivalent in the center-south region (150 days operation and 10 percent opportunity cost for all capital); (d) Barzelay[24] with Copersucar's data for the center-south region, US$ 86.10 per barrel equivalent.

These other estimates also lend support to those reported in Table 1 and, in particular, indicate the great importance of eliminating the credit (interest rate) subsidies when analyzing alcohol production costs with the objective of getting a "true" figure. In addition, our results indicate that, unless the situation represented an extreme emergency and there was no possibility of increasing output from other lower cost alternatives, the emphasis on alcohol was very much exaggerated in the 1979 Brazilian energy program vis-a-vis those other alternatives. The disregard for economic considerations existing at that time seems also to be present in the unofficial scenario proposed by the Ministry of Energy in July 1984.[25] In that scenario, while alcohol production is contemplated to increase from 77,000 barrels equivalent-day in 1983 to 256,000 in 1993, charcoal would increase only from 79 to 116 barrels equivalent-day. The investments needed from 1984 to 1993 would be US$ 6.5 billion for alcohol and US$ 2.0 billion for wood[26] Consequent to the increase in sugarcane production for transformation into alcohol, in the above scenario is included an increase in bagasse production from 126,000 barrels equivalent-day in 1983 to 241,000 in 1993. On the favorable side of that scenario is the substantial increase in the production of domestic oil, natural gas and mineral coal.

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[22]Borges, J.M.M., "Desenvolvimento Economico, Politica Energetica e Alcool" mimeo, Sao Paulo, August 1980. Copersucar is a "cooperative" of private sugar and alcohol firms.

[23]Williamson, C., "The Impact of the Brazilian Alcohol Program on Food Supply and Nutritional Status", Harvard University, mimeo, April 1981.

[24]Matar, H., Programa Energetico Nacional: Possibilidades e Impactos, Instituto de Pesquisas Tecnologicas, Sao Paulo, 1980.

[25]Barzelay, M., "The Political Economy of Alcohol Energy in Brazil". Report 5-3, Institute for Energy Studies, Stanford University, 1980.

[26]Ministerio das Minas e Energia, Auto-Suficiencia Energetica: Um Cenario de Extensao do Modelo Energetico Brasileiro. Republica Federativa do Brasil, July 1984.

[27]The increase in wood production predicted in the scenario between 1983 and 1993 is 201,000 barrels equivalent-day and charcoal.

Chapter 4: Equity Implications of the Alcohol Program

Three equity implications of the alcohol program will now be discussed, although much more briefly than our previous analysis: first, is the critical aspect of effects of increased sugarcane (alcohol) production on the land area and output of domestic food crops; second, is the impact of the program on employment and seasonality of labor use in a given region. Finally, there is the question of who really are the beneficiaries of the increased production and use of alcohol in the economy.

In Table 2 we present the growth in Brazilian agricultural production per capita from 1977 to 1984, disaggregated into domestic food crops, exportables, sugarcane, and meats. Because the alcohol program was officially introduced in November 1975, the year 1977 is the adequate one to serve as the base year. We can then note that per capita production of domestic food crops declined 1.94 percent yearly during those years, at the same time that per capita production of exportables grew 2.56 percent yearly; sugarcane, 7.84 percent per year; and the production of meats remained constant. This type of performance confirms our earlier prediction that a rapid increase in sugarcane

Table 2. Rates of growth of per capita production in Brazilian agriculture, 1977/84 (1977 = 100)*

YEAR	DOMESTIC FOODS	EXPORTABLES	SUGARCANE	MEATS
1977	100.0	100.0	100.0	100.0
1978	86.0	88.0	105.1	97.8
1979	87.3	94.0	110.5	95.8
1980	90.8	112.8	115.6	97.9
1981	90.2	110.6	118.3	103.7
1982	96.5	104.2	137.9	106.6
1983	73.6	107.2	156.4	103.0
1984	84.9	113.3	174.8	99.1
Growth Rate %	-1.94	2.56	7.84	Zero

*Laspeyres indices, 1977's prices, population growth of 2.5 percent during 1977/80 and 2.3 percent during 1980/84. Domestic Foods: rice, edible beans, mais, cassava and potatos; Exportables: cotton, groundnuts, tobacco, soybeans, oranges, and cocoa; Meats: beef, pork and poultry. Significance tests at the 20 percent level.

production, together with the needed increase in exportables (the latter because of the external debt), would negatively affect domestic food production through increased competition in factor markets, especially in the land market.[27]

In addition, the seriousness of the food problem in Brazil can be illustrated by the following information about the behavior of the real minimum wage (the nominal minimum wage deflated by index of retail food prices) during the 1977-84 period. In the city of Rio de Janeiro in 1978, for just 0.9 percent was the real minimum wage above the level of 1977. During the 1979-82 period it was 5.0-8.8 percent below 1977's level, and in 1983 and 1984 the declines were 25.9 and 36.0 percent, respectively. Also, in Porto Alegre (Rio Grande do Sul) the pattern from 1977 to 1984 was quite similar to that for Rio de Janeiro. Only in Sao Paulo was the experience somewhat better (lower declines), but even so, in 1984 the real minimum wage was 12.0-23.5 percent below 1977's level. In summary, the increases in the nominal minimum wage by the government were below increases in food prices.

In such a context, it is interesting to review the results of Tourinho, et al,[28] with a dynamic linear programming model: "... it can be noted that for alcohol as well as for exportables (soybean) and for domestic crops (maize, rice, and edible beans), the shadow price in Ribeirao Preto increases when higher alcohol demands are considered. The difference is larger the more intense is the competition of the crop with sugarcane. This same type of effect is also observed in the other regions of the model." This is an additional and worrisome possibility, mainly with regard to the performance of food crops just described, as well as with the chances of further increases in alcohol production in the present decade.

With respect to the employment question, it seems that the impact of the alcohol program is favorable in terms of total number of working days created in agriculture, but unfavorable in terms of seasonality. Our evaluation for the state of Sao Paulo, the most important in sugarcane production, indicated for the period 1976-80 an increase of 15.2 percent for the total number of working days in agriculture, as well as an increase of 16.2 percent for tractor operators. These increases were caused basically by the changes in the state's crop mix, a process which was led by sugarcane production and followed by coffee, edible beans, and oranges.[29] At the same time total temporary employment was growing in Sao Paulo during the 1976-80 period, there were indications of aggravation in the monthly distribution of that employment, that is, employment tended to occur in a more seasonal pattern,

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[27]See Homem de Melo, F. and E.G. Fonseca, Proalcool, Energia e Transportes op.cit., chapter 3. We estimated that to accomodate the required growth (as viewed in 1979-80) in food, exportables, and sugarcane production, cultivated acreage needed to increase 6.6-7.0 percent yearly. The historical growth rate in this area has been 3.5 percent yearly, which indicates the possibility of a conflict among goals.

[28]Tourinho, O.A.F. et al., Agricultura e Producao de Energia: Um Modelo de Programacao Linear para Avaliacao do Proalcool, op.cit., p. 68.

[29]See Homem de Melo, F. and E.G. Fonseca, Proalcool, Energia e Transportes, op.cit., pp. 82-94.

concentrated in the period between May-June to August-September of each year. This was later confirmed by Toyama[30] with a model of recursive linear programming for the region of Ribeirao Preto in the state of Sao Paulo.

In addition, the study done by Coalbra,[31] the federal company charged with the production of alcohol from wood (a pilot plant), estimated that when the 1985 target for the alcohol program was completed there would be a total of 510,000 man-years of employment (gross, that is, not considering the loss of employment in substituted crops). However, only one third of that would be permanent employment. Two thirds would be temporary employment in harvesting and industrial transformation. This, according to Coalbra's evaluation, should alter not only the structure of employment but also migration between and within states. Finally, the same study estimated a cost of US$ 22,000 for employment creation in the alcohol program[32] (US$ 30,000 for alcohol from wood) and concluded: "these figures are comparable to, and perhaps higher than, capital requirements for employment creation in the modern industrial sector. As a result, employment is not a special advantage of Proalcool."[33]

Lastly, a word about beneficiaries of the alcohol program in addition to those directly involved (planters, industrial producers, capital goods industry, etc.). With data from the national family budget survey of 1974-75, we can observe the following: First, the relative expenditures (shares) devoted to automobiles (gasoline, maintenance, etc.) in the state of Sao Paulo increase as total expenditure increases up to a point equal to 15-20 minimum wages (15-30 in the state of Rio de Janeiro). Second, relative expenditures devoted to mass transport in Sao Paulo are more important in family budgets than those devoted to automobiles in expenditure classes below 3.5-5.0 minimum wages (5.0-7.0 in Rio de Janeiro). This information indicates that the beneficiaries of the alcohol program, through the substitution of alcohol for gasoline at lower prices and by favoring individual transportation instead of mass transportation, will be concentrated for families with middle and high incomes. In the state of Sao Paulo, the one with the highest per capita income in Brazil, 22 percent of the families had expenditures above seven minimum wages in 1974-75 as well as the ownership of 86 percent of the automobiles.[34]

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[30]Toyama, N., Crescimento Agrícola e Emprego: O caso da Regiao de Ribeirao Preto nos Anos 70. Master's dissertation, Dept. of Economics, University of Sao Paulo, 1982.

[31]Coalbra, Alcool e Emprego: O Impacto da Producao de Alcool de Cana-de-Acucar e de Madeira na Geracao de Empregos. Cadernos Coalbra No. 3, Ministry of Agriculture, 1983.

[32]Such a high cost of employment creation is attributed to the high capital requirements in the industrial phase of alcohol production. This confirms our earlier analysis about the great importance of capital costs in total alcohol costs.

[33]Coalbra, O Impacto da Producao de Alcool de Cana-de-Acucar..., op.cit., p. 165.

[34]Quite similarly to Sao Paulo, in the state of Rio de Janeiro, 22 percent of the families had the ownership of 85 percent of the automobiles.

The most recent data for Brazil as a whole indicate that in 1983 only 17 percent of the homes had automobiles. As a result, low income families will benefit relatively little with the alcohol program, as compared to mid/high income families.

Chapter 5: Final Comments

This paper covered several aspects of the alcohol program in Brazil. First, we described the antecedents of the program, its creation, and the main incentives provided to different agents with the objective of obtaining increased production and consumption. Second, we discussed economic aspects, not only specifically for alcohol but for several alternatives to oil products as well. Third, we analyzed three possible equity implications of the program, that is, effects on domestic food production, on agricultural employment, and on distribution of benefits. Without repeating what was reported in the text, we should say that our analysis leads us to conclude that alcohol production in Brazil cannot be justified in economic (social) terms. Production costs are very much too high, the country has lower-cost alternatives to oil products, and the equity consequences are unfavorable. The country would gain more in terms of foreign exchange savings by reallocating investments towards other alternatives, including domestic oil, natural gas, mineral coal, charcoal, shale oil, and conservation (including improved transportation systems).

Two reasons might be suggested to explain the creation and expansion of the alcohol program in Brazil under these unfavorable economic and social conditions. In the first place, a powerful coalition of interests existed, including sugarcane and alcohol producers, the capital goods industry, the automobile industry in phase two, and middle and high income families as consumers. The argument based on the balance of payments crisis was an important one, although imperfect since it did not consider other alternatives to oil products in what would be a more complete analysis. However imperfect, the supporters of the alcohol program could present dollar (savings) figures to justify its implementation. Criticism based on the determination of better alternatives and higher dollar savings was more complex, and difficult to understand for the general public, outside a small group of economic researchers, after the program was started and production was taking place.

A second reason to be mentioned is related to the technical aspects of the different alternatives, as well as to the uncertainties attached to some of them. Since Brazil's experience with sugar and alcohol production is quite extensive, the technology is well known, including that in the capital goods industry, and an alcohol program would rank well in the technical dimension. In comparison, a greater uncertainty would be associated, for instance, with the technology for shale oil production, since Brazil's only experience is with a pilot plant. However, the same could not be said for mineral coal, charcoal, domestic oil, and natural gas. With respect to domestic oil, the only problem would be the uncertainty of finding new reserves. In a critical situation with the balance of payments, the technical advantages and less uncertainty of alcohol vis-a-vis some of the other alternatives may have been factors justifying the decisions of policymakers to favor the introduction of the alcohol program. If, however, that happened in 1975 (phase one) and again in 1979 (phase two), against the economic/social evidence reviewed in this paper, it cannot be accepted as a permanent argument to validate the additional future expansion of the alcohol program. Today Brazil has an oil production of almost 600,000 barrels per day (about 60 percent of total

consumption), new reserves are being discovered, natural gas is available, and mineral coal and charcoal production present no major problem. Also, conservation, including improved transportation systems (urban and long distance), could well have a more prominent place in a plan for saving oil products. However difficult is the breaking of the political forces supporting the alcohol program, we must keep clearly in mind the economic and social aspects reported in this paper, so that society becomes well aware of the trade-offs involved.