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Viability of Ethanol Motor Fuel in Brazil: Cost-Benefit Considerations

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SUMMARY

The study assesses the viability of ethanol fuel considering both private and social costs and benefits. Ethanol costs are calculated for different production scales, locations, and government subsidies. The results show that without government financing subsidies, ethanol fuel would be privately economical (at May 1981 prices) only in Southeast distilleries of appropriate scale. Northeast distilleries are uneconomical even with a shadow wage for labor. Foreign exchange savings from ethanol production are calculated, with the finding that relatively small savings are achieved. However, Brazil gains greater flexibility in sugar export earnings by being able to alter the production mix of ethanol and sugar depending on international prices. Social benefits of ethanol production include greater rural employment, the creation of rural industrial development "poles," and national strategic considerations. Yet ethanol from sugarcane has also displaced food crops, contributed to greater land concentration, and not reduced regional disparities.

I. INTRODUCTION

The Brazilian Alcohol Fuel Program (Proalcool) was conceived from the union of two political forces, which for simplicity may be labeled economic and social. The economic force was the rise in petroleum prices, and the practical necessity for Brazil to produce domestically more liquid fuel. Ethyl alcohol from sugarcane had been added to gasoline in Brazil in varying amounts since the 1930s, and was the logical short-term choice. A contributing factor was the depressed world sugar market, which left many sugar mills looking for alternative uses for cane. The social force for the alcohol program derived from the necessity to improve conditions in rural areas to stem the migration of population into urban areas. Thus Proalcool was born with two overriding goals: to produce efficiently and abundantly a fuel to substitute for imported petroleum-based gasoline; and to be an instrument of social progress, to improve income distribution and the opportunities for small farmers.

There has been considerable debate in the press and in professional papers questioning the methods and goals of Proalcool.[1] This paper examines the viability of ethanol production from the producers' perspective (private costs and benefits), and then turns to examine viability from society's perspective (social costs and benefits). The former is a relatively straightforward calculation of actual costs of production, the actual revenues, the resulting profits or losses, and the rates of return to private ethanol producers. The calculation of social costs and benefits is done on the basis of real opportunity costs of resources used and the social benefits resulting from production. Because of market imperfections and government intervention, the two are usually different.

In the case of ethanol, government intervention in the market is pervasive, setting prices for sugarcane and alcohol, providing capital subsidies, and the government oil monopoly Petrobras being the sole marketing agent. Consequently, private and social costs are substantially different. Section II estimates the private costs and benefits and Section III the social costs and benefits of ethanol fuel in Brazil.

II. PRIVATE COSTS AND BENEFITS

To promote alcohol production the Brazilian government provided 80-90% of distillery investment financing at nominal interest rates well

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[1] The most recent criticism is of Michael Barzelay and Scott R. Pearson, "The Efficiency of Producing Alcohol Energy in Brazil," Economic Development and Cultural Change 31 (October 1982), pp. 131-144.

below the rate of inflation. These loan rates varied slightly by location, type of distillery and type of raw material. Over the period 1976-80 nominal interest rates averaged twenty-one percent per year while inflation averaged sixty-three percent. Thus the real interest rate on average was negative forty-two percent. In 1981, facing a financial crisis, the government raised nominal interest rates but still maintained a negative real interest rate of eight percent.

Ethanol costs of production are estimated in Table 1 under pre-1981 and 1981 financing arrangements for both the Northeast and Southeast sugarcane regions. Costs for four distillery sizes are shown: "micro" (5,000 liters/day), "mini" (30,000 l/d), "small macro" (120,000 l/d), and "large macro (300,000 l/d). The figures are expressed in U.S. dollars per gallon, at May 1981 prices (Cr$83.67/U.S.$). Data come from field research conducted during eleven months in 1980-81.[2]

Under pre-1981 financing, in which the subsidy on capital was greatest in real terms, the 120,000 liter per day plant produced at the lowest cost, US$0.70/gallon in the Southeast and US$1.06/gallon in the Northeast. Under the stricter financing terms in 1981 the 30,000 l/d plant produced at lowest cost, US$0.99/gallon in the Southeast and US$1.39/gallon in the Northeast. These scale effects appear because distilleries of different daily capacities have different capital intensities. Capital-intensive plants (like the 120,000 l/d) benefit relatively more from subsidies to capital.

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[2] For an in-depth report, see Jonathan B. Wight, "Economies and Diseconomies of Scale in Ethanol Fuel Production: The Case of Brazil," Ph.D. dissertation, Vanderbilt University, 1982.

TABLE 1

PRIVATE COSTS OF ETHANOL PRODUCTION BY SCALE, LOCATION, AND FINANCING TERMS (US$/GALLON AT MAY 1981 PRICES)[a]

Scale of Production (liters/day)	Southeast		Northeast	
	Pre-1981 Financing	1981 Financing	Pre-1981 Financing[b]	1981 Financing
5,000 "micro"	1.21	1.14	1.78	1.70
30,000 "mini"	0.72	0.99	1.07	1.39
120,000 "small macro"	0.70	1.05	1.06	1.49
300,000 "large macro"	0.77	1.00	1.19	1.48

Source: Jonathan B. Wight (1982, p. 173).

[a] Cr$83.67/U.S.$

[b] Financing terms for the Northeast pre-1981 are slightly more advantageous than for the Southeast. This difference has been included in the analysis.

Is ethanol production viable under private cost/benefit calculations? These results show that it is, with notable caveats. The government-set price for purchasing hydrated alcohol at the factory gate in May 1981 was U.S.$1.14/gallon in the Southeast and U.S.$1.21/gallon in the Northeast. In the Southeast all size distilleries considered are economically viable under both pre-1981 and 1981 financing schemes, with the exception of the micro under pre-1981 terms (which received no government financing prior to 1981). In the Northeast all plants except the micro are viable under the pre-1981 terms but all become inviable with the stricter 1981 terms. Thus the higher financing costs in 1981 severely limited the participation of the Northeast in Proalcool.

The private cost calculations of ethanol production vary significantly from the social cost calculation, as shown in the next section.

III. SOCIAL COSTS AND BENEFITS

Social costs of production value resources at their opportunity costs, regardless of government financing schemes, minimum wage laws, or other distortions. Financing is based on the real opportunity cost of capital, assumed to be ten percent.[3] In the Southeast, labor is scarce enough for wages to reflect true opportunity costs (Borges, 1980, p. 41; World Bank, 1981, p. 48), while in the Northeast a shadow wage is appropriate. A shadow wage of 70 percent is used, which is the rate employed by the World Bank in analyzing projects in the Northeast (1981, p. 48). The main effect of the shadow wage will be to lower sugarcane costs, since roughly 36 percent of the cost of sugarcane derives from payments to unskilled workers, while very little direct labor is used in ethanol production (Borges, 1980).

Accounting for the opportunity costs of capital and labor allows an estimate of social costs of production, found in Table 2. The analysis is partial, since not all inputs have been evaluated at their opportunity costs--e.g., land, agricultural capital, and imported inputs. The figures show that only the 30,000 l/d and 300,000 l/d plants in the Southeast are viable when government subsidies are eliminated--again using the set price of US$1.14/gallon in the Southeast and $1.21 in the Northeast as benchmarks. Of course, the appropriate measure of project desirability is to compare the social costs with the social benefits, not the fixed price set by the government.

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[3] Selecting an opportunity cost of capital 100 percent higher or 100 percent lower does not alter the basic findings (Wight, 1980, p. 159).

TABLE 2

PARTIAL ANALYSIS[a] OF SOCIAL COSTS OF ETHANOL PRODUCTION BY SCALE AND LOCATION (US$/GALLON AT MAY 1981 PRICES)[b]

Scale of Production (liters/per day)	Southeast	Northeast
5,000 "micro"	1.21	1.61
30,000 "mini"	1.12	1.43
120,000 "small macro"	1.23	1.58
300,000 "large macro"	1.12	1.50

[a] This analysis considers the real opportunity cost of industrial capital at 10 percent per year, and industrial and agricultural unskilled labor in the Northeast at 70 percent of private cost. The analysis is partial since not all inputs are evaluated at their opportunity costs.

[b] Source: Wight (1982, p. 176).

The massive push to promote alcohol fuel was based on a larger development strategy which sought to unite public support for the program. While the main goals of the program are to promote foreign exchange savings and stabilize earnings in the sugar industry, other stated economic and social goals are:

--Greater self-reliance and independence from potentially unreliable foreign sources (Brazil's main oil suppliers are Iraq and Saudi Arabia).

--Reversal of the trend of rural-to-urban migration.

--More balanced inter-regional growth as the Northeast becomes a major alcohol supplier.

--Improved distribution of income with opportunities for small farmers.

--Revitalized domestic capital goods industry which will provide most of the distillery equipment.

--Diminished pollution from cleaner-burning alcohol.

--Potential for Brazil to become the world's technological leader in alcohol production and use.

This paper evaluates three of the stated goals, namely, foreign exchange savings, national energy security, and rural development.

Foreign Exchange Savings

Determining the magnitude of foreign exchange savings is not a simple one-to-one calculation. First, while alcohol cars have better performance than gasoline cars in terms of acceleration, miles per gallon is about 25 percent less (Quatro-Rodas, 1980, pp. 36-42). Second, gasoline represents only about 23 percent of refined petroleum production in Brazil -- with 27 percent being diesel oil, 28 percent home heating oil and 22 percent naphtha, kerosene, asphalt, and other by-products (CNPq, 1980, p. 210). Even though ethanol may substitute as fuel for gasoline, there is a higher demand for other petroleum products such as diesel fuel, and thus greater amounts of petroleum must be imported regardless.

The true cost of gasoline in Brazil is difficult to determine since refineries receive government financing, and the refineries, built before the oil shock, are now operating with excess capacity. On a retail level the price of gasoline is maintained about 40 percent higher than for alcohol to stimulate ethanol use, through the use of excise taxes. Compared with international prices, gasoline on the spot market in

Rotterdam (May 1981) is US$0.98/gallon (Conjuntura Economica, 1982) which is 12 percent below the lowest social cost of ethanol produced in Brazil (US$1.12/gallon).

Even this comparison is misleading because the production of sugarcane utilizes a fair amount of petroleum itself. Diesel fuel for sugarcane land cultivation amounts to 312 liters per hectare of cane, or about 9 liters of diesel used for each 100 liters of alcohol produced (assuming 3,500 liters/ha) (CNPq, 1980, p. 214). There are additional petroleum outlays for cane transportation, fertilizers, pesticides, and herbicides. The alcohol waste stillage has a fertilizer value which diminishes however, the need for chemical fertilizer.

The production of ethanol requires other imported inputs, particularly enzymes and stainless steel. For each ten thousand liters of alcohol capacity, about 1.3 tons of imported stainless steel is needed. Thus to produce 4.5 billion liters of yearly ethanol capacity (assuming 150 production days per year) requires about 4,700 tons of stainless steel (CNPq, 1980, p. 227).

In an attempt to quantify the petroleum savings from producing 4.5 billion liters of ethanol and using it as a fuel, the National Council for Scientific and Technological Research (CNPq, 1980, p. 229) evaluated costs based on 1976 prices and petroleum valued at US$12.20 per barrel. Their results are that each liter of alcohol used as fuel saves about 6.5 U.S. cents in imported petroleum. If about 4.5 billion liters of alcohol were produced, this would generate almost US$300 million in foreign exchange savings. This figure is far less than the total petroleum import bill of US$3.6 billion in 1976. With petroleum prices at US$34.28

per barrel in 1981, undoubtedly the foreign exchange savings are greater, but no so great as alcohol proponents would like. Clearly alcohol is not a panacea for the petroleum import problem.

The argument can also be made that even though ethanol fuel generates positive foreign exchange, greater amounts of foreign exchange could be earned by not using ethanol as a fuel, or not producing ethanol at all but using those resources to produce some other export-oriented product. As an example of the first case, ethanol sold as a chemical (on domestic and export markets) would generate 39 U.S. cents of net foreign exchange as opposed to the 6 U.S. cents generated by its use as a fuel (CNPq, 1980, p. 230; Borges, 1980, p. 47). As an example of the second case, sugarcane could be used to produce more sugar for export rather than alcohol.

Brazil gains a great flexibility in being able to use sugarcane for producing either sugar or alcohol, depending on the relative international prices of these commodities. Borges (1980, p. 48) calculates that after meeting internal demands for sugar and minimum export quotas for sugar set by the International Sugar Accord, Brazil in 1980 had about 32 million tons of sugarcane which could be used to produce either 3 billion kgs. of sugar or 1.8 billion liters of ethanol for use as a chemical. That is, the production trade-off is one liter of alcohol for each 1.67 kgs. of sugar.

If the relative international price ratio of ethanol to sugar is greater than 1.67, then clearly ethanol should be produced and exported to maximize foreign exchange earnings. Based on the 1980 international sugar price of US$0.60 per kg. of sugar and US$60 per barrel or US$0.38 per litter of ethanol, the ratio of alcohol to sugar prices is 0.63, which is lower than the 1.67 production ratio. Sugar should be exported, generating US$1.8 billion in foreign exchange; if alcohol had been exported only US$684 million would have been earned. In 1978, however, with sugar selling for US$0.17/kg., a different policy would have been recommended.

This calculation assumes quite importantly that the international sugar price would not change given Brazil's export decisions. Orden and Schuh (1980, p. 17) argue that this is a reasonable assumption, and using data for 1979 they calculate a hypothetical loss of almost US$2 billion in foreign exchange if Brazil had produced 7.6 billion gallons of ethanol (to substitute for petroleum) rather than producing sugar for export (valued at US$0.28/kg.).

The assumption of perfectly elastic sugar demand must be viewed with skepticism, however, considering the large price oscillations observed in the international market. During 1977 and 1978 the Brazilian government sought to maintain international prices by building up sugar stocks equal to 33 percent of world sugar consumption (Borges, p. 60). Furthermore, the World Bank's sugar commodity model shows that if Brazil used its 1985 sugarcane production exclusively for sugar, this would amount to 40% of world sugar trade; international sugar prices would fall by 50 percent (The World Bank, 1981, p. 46). Brazil's share of world sugar trade would need to increase from 9 percent to 45 percent to dispose of this sugar, in conflict with International Sugar Agreements. Thus the option of exporting significantly greater quantities of sugar presents obstacles. This should not imply that ethanol is necessarily the best alternative. Other export crops, such as soybeans or cotton, might easily be preferable to ethanol in terms of the opportunity cost of resources.

Strategic and Social Benefits

Proponents of the alcohol program argue that in addition to the external economic benefits significant strategic and social benefits will be realized: 1) increased national energy security, and 2) increased rural development (particularly in the Northeast).

1) National Energy Security

The first strategic benefits were realized sooner than expected when in September 1980 war broke out between two of Brazil's oil suppliers -- Iran and Iraq. Virtually overnight 40 percent of petroleum imports were cut off. A difficult period ensued, but by raising the proportion of alcohol in gasoline to 30%, instituting voluntary conservation measures, and making spot purchases of petroleum, a major economic and political crises was averted. In addition, Proalcool helped maintain automotive sales at around a million units a year from 1975-80,[4] leading planning minister Delfim Neto to laud:

> . . . [Proalcool] is today a fundamental instrument for maintaining the automobile industry, without the expansion of which the whole level of development of this country would suffer terribly.[5]

Proalcool thus gained recognition and respect for the role it played in easing political, economic, and social pressures in the late 1970s.

2) Rural Development

A principle social objective of Proalcool is to improve agricultural conditions by establishing rural industrial poles, which serve to raise

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[4] Due to the recession, sales fell to 800,000 units in 1981.

[5] Quoted in O Estado de Sao Paulo, 27 November 1980, "Delfim: Proalcool e Fator Inflationario" (Author's translation).

incomes, generate employment, and reduce migration to cities.[6] Unfortunately, the tighter financing terms in 1981 effectively cut the Northeast off from further ethanol development. Of 390 distillery projects approved by May, 1981, over two-thirds are located in the Center/South and less than one-third in the North/Northeast. Thus regional disparities between the traditional sugarcane regions in the Northeast and Southeast are not likely to diminish (and may increase) as a result of Proalcool.

The massive push to increase sugarcane cultivation resulted in the substantial development of unused or frontier lands, particularly in the Center/West regions. Autonomous[7] distilleries require the sugarcane area expansion of 2.2 million hectares by 1985 (Table 3). Sugarcane represents six percent of total Brazilian cropland use in 1980 and will represent nine percent in 1985, assuming a growth in total cropland. In the Southeast, displacement of other crops and livestock pastures is occurring. In six subregions in Sao Paulo the new sugarcane land is calculated by Pelin (1980, p. 835) to come fifty-one percent from displacement of domestic food products (rice, beans, and corn) and forty percent from pastures. Displacement is also found in the South by Matuella (1980, p. 823).

Sugarcane is a relatively labor-intensive crop as shown in Table 4. If sugarcane displaces soybeans, oranges, rice, or corn the job generation will be significant, but if it displaces cotton or peanuts jobs will be lost in the agricultural sector. Borges (1980, p. 770) calculates

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[6] Alcohol is particularly suited for this since excess sugarcane stalks (bagaco) can be burned to provide electricity in rural areas.

[7] I.e., not attached to sugarmills.

TABLE 3

LAND AND SUGARCANE REQUIREMENTS TO MEET 1985 ALCOHOL GOALS[a]

Area Location	Area (000s of Ha)	Cane Production (000s of tons)	Alcohol Production (millions of liters)
1. Traditional	2,300	126,500	2,837,750
2. Expansion of Traditional	460	25,300	1,771,000
3. New	1,740	87,018	6,091,250
4. Total	4,500	239,000	10,700,000

Source: Luiz Carlos Correa Carvalho, "Sistema de Pesquisa no Brazil Para a Agroindustria da Cana-de-Acucar" (Piracicaba, S.P., PLANALSUCAR, May 1980).

[a] These are the goals as of May 1981.

TABLE 4

LABOR UTILIZATION IN VARIOUS CROPS

Crop	Days of Work Per Year Per Hectare	
	Non-Skilled	Skilled
Cotton	60.0	3.0
Soybeans	3.0	1.3
Oranges	19.1	2.7
Peanuts	41.0	3.0
Rice	25.0	3.0
Corn	6.0	2.7
Sugarcane	28.0	3.4

Source: Caron (1980, p. 735)

that by 1985 about 350,000 jobs will be generated directly by the ethanol program -- 80,000 in distilleries and 270,000 in agriculture. Considering dependents about 1.1 million persons will be supported in rural areas by the ethanol program. Accounting also for the indirect job creation in the domestic goods industry, the automotive industry, and the general multiplier effect of the higher incomes, the number of rural and urban jobs created is of significance.

IV. SUMMARY AND CONCLUSIONS

Almost all observers agree that ethanol fuel would not be economically viable in Brazil without substantial government subsidies, particularly in the North/Northeast. (Borges, 1980; Poole, 1979; CNPq, 1980; Wight, 1982). Whether such subsidies are justifiable depends on the positive externalities of production and consumption. Ethanol fuel use does save foreign exchange, but not substantial amounts; and, until an alcohol-diesel engine is developed, petroleum dependency is maintained. Nevertheless, ethanol capacity does provide strategic benefits by making Brazil less vulnerable to import short falls, and providing a boost to the automotive and sugar industries.

In the rural sector Proalcool has contributed to the massive development of new lands along with the appropriation of existing croplands and pastures. This has incidentally resulted in a growing concentration of land ownership, at a time when land tenure questions threaten rural stability (Wight, 1982). Regional disparities between the Northeast and Southeast will likely not diminish (and may increase) because of continuing large production cost differences. Thus in the final analysis social aspects of the program are not conclusively beneficial.

The recent oil-price rollbacks of February 1983 reduce the external economic benefits of Proalcool and thus reduce the impetus for its expansion. This, plus the fiscal austerity demanded by Brazil's I.M.F. recovery package, has put the alcohol fuel program on hold. Despite the difficulties, one cannot help but admire this ambitious and innovative alternative energy effort, in contrast to the "coy mistress"[8] who prevails over U.S. energy policy-making.

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[8] Poole, 1979, p. IV.

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