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# REGIONAL AND FARM LEVEL ADJUSTMENTS TO THE PRODUCTION OF ENERGY FROM AGRICULTURE: BRAZIL'S ALCOHOL PLAN

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## Introduction

An impending world shortage of oil has prompted many to call the energy crisis a liquid fuel problem. This is especially true for Brazil where a commitment to major use of liquid fuels is responsible for a serious emerging energy problem. About 80 percent of Brazil's petroleum needs are imported, and petroleum price increases since 1974 have severely strained the balance of payments. Domestic supplies of oil and coal are inadequate and show little promise of ever meeting more than a small percentage of domestic energy needs. In response to this situation, Brazil has adopted some short run policies to slow the growth in demand for petroleum products. More importantly, Brazil is implementing a pioneer plan to produce a significant amount of its liquid fuel needs in the form of alcohol derived from sugarcane, cassava, and other energy crops. This effort presents the world with the first major experiment in the commercial competition between food and energy production.

The outcome of this experiment is generally important for a world short of both energy and food. It is of special interest to many developing countries located in tropical areas with limited fossil fuel reserves. For many of these countries, energy from biomass, and specifically liquid fuel production, may be an attractive alternative to costly oil imports. Brazil represents many developing country characteristics, having biomass production potential, limited fossil fuel reserves, and foreign exchange problems exacerbated by a heavy oil import bill. Brazil does, however, have abundant land resources. Alcohol production is being initiated on prime developed agricultural land (Sao Paulo), and the research results reported below do not consider an expansion of agricultural land area.

The purpose of this paper is to report initial results of a farm level regional analysis of the Brazilian alcohol plan. Alcohol production from energy crops is presently not competitive with world oil prices. However, within Brazil, a price regulated energy market insures a competitive price for alcohol. The analysis examines both the regulated market and a free market for energy. The free market analysis is conducted to measure the anticipated response to rising energy prices.

Energy price increases are reflected in regional farm level models in several ways, including derived farm level prices for energy crops, differential energy inputs to farm production technologies (mechanized and nonmechanized), uses of specific technologies by farm size, energy inputs to alcohol processing, and transportation costs of raw products and alcohol to processing plants and distribution centres. Energy prices are set at various levels in specific regions, with both regional and central demand centres competing for the final product. Regional land and labour use, crop competition (between sugarcane and cassava, and between food and feed crops), and technological change (energy intensity) are all studied in relation to energy price changes and volume of energy production.

## The Alcohol Plan

The alcohol plan is a product of the energy realities faced by Brazil and the agricultural potential for producing alcohol. Over the past 20 years, Brazil has embarked on an ambitious industrialization programme that has relied substantially on an automobile industry, truck transport, and areas of highly mechanized agriculture. This path of development has necessitated a strong reliance on petroleum as a source of energy to supply the liquid fuel needs of the

automobile and truck transport sectors. Imports have accounted for 80 percent of petroleum needs, and lack of major fossil energy sources has forced the country to initiate a search for other sources of energy while controlling internal consumption of petroleum products. Brazil has been using a limited amount of alcohol mixed with gasoline (gasohol) for many years. This alcohol has been produced as a byproduct of a substantial sugar refining industry.

In 1975, Brazil initiated a plan to increase the alcohol production from sugarcane and to investigate the possibility of using other crops, especially cassava, sweet sorghum, and babacu (palm) for alcohol production. The long run goal is to replace most petroleum needs with domestically produced alcohol. A public control system was also established to develop and control the production and distribution of alcohol, to fix prices and conversion quotas, and to propose new policy measures for the future development of the alcohol plan.

The initial goal was to produce about 2.6 billion litres of alcohol a year by 1980, equal to about 20 percent of all gasoline consumed in the country in 1975. This alcohol is to be utilized in a mixture with gasoline. Initial alcohol production and use has occurred in the established sugarcane areas near major consumption centres such as Sao Paulo. However, it is felt that regional production of alcohol will be both desirable and necessary in order to meet the production goals in the alcohol plan, to spread alcohol use throughout the country, and to provide a broader distribution of the expected income and employment increases associated with expanded alcohol production. Thus, new areas, with substantially different agricultural production resources and crop alternatives, are to be integrated in the plan.

The plan has significant implications for a broad spectrum of domestic and international activities for Brazil. The dimensions of these issues are only beginning to be recognized and addressed. The private sector is reluctant to undertake substantial capital investment in distillery plant capacity, knowing that the cost of petroleum is still below alcohol production cost. Therefore, rapid expansion of distillery capacity must be based on government support and incentives.

In addition, there is competition for the use of basic resources for the production of sugar, alcohol, and other exportable crops, and a tradeoff between them and imported petroleum. Price relationships will naturally be an important determinant of the allocation of these resources. Thus, emphasis in the analysis was placed on resource competition within the agricultural sector as determined by international and domestic price relationships between petroleum, alcohol, sugar, cassava, and other competitive domestic crops.

### Regional Farm Level Models

Four regions were selected for study. The first is Campinas, in the State of Sao Paulo, representing the most concentrated sugarcane production area in Brazil. This area is characterized by large mechanized farms in a labour deficit area. It is located near the largest consumption centre of Brazil--the city of Sao Paulo. Contrasting with this area are three other regions selected from the southern states of Brazil--two in Santa Catarina and one in Rio Grande do Sul. These areas represent regional production and consumption centres in which small farms predominate in a labour surplus area.

Rio Grande do Sul has a major regional consumption centre, the city of Porto Alegre, and a regional production area with both sugarcane and cassava. Agricultural technology is intermediate, with both modern mechanized and small traditional farms. Santa Catarina is a minor regional consumption area, but a major regional production area, with mostly small farms, surplus labour, and traditional technology. It has subregions with both sugarcane and cassava and with cassava only. The regions selected thus represent a cross section of alcohol production and consumption conditions for testing the impacts of the alcohol

programme.

The model for analysis was defined at three levels: agricultural production, alcohol processing, and alcohol and gasoline blending and marketing, with connecting transport linkages. Special emphasis in the analysis, however, is given to agricultural production where the alcohol producing crops—sugarcane, cassava, and eucalyptus (firewood)—compete with other agricultural products for land and labour resources. Five different processing activities are established using sugarcane, cassava, or both as raw materials for alcohol production. Finally, four mixing plant locations (consumption centres) are defined in Campinas (Sao Paulo), the city of Sao Paulo, Itajai (Santa Catarina) and Porto Alegre (Rio Grande do Sul).

### Analysis and Conclusions

The analysis was conducted in two parts: first, the 1976 (base year) price and policy relationships were used to estimate alcohol production and use relationships under conditions existing then. In 1976, diesel oil—used mostly for agricultural production and merchandise transportation—was priced at Cr\$2.07 per litre at the retail level. The retail gasoline price was Cr\$4.07 per litre and the alcohol wholesale price was Cr\$3.26 per litre. The minimum wage rate of Cr\$4.36 per hour was adopted for the region of Campinas, which is a labour deficit area. For the other regions, a value of Cr\$3.00 was used. Under these conditions, alcohol was competitively produced in the model at all four production regions, mostly for local consumption.

In the second part of the analysis, a free market price system for energy was simulated to test the competitiveness of alcohol production and its effect on resource allocation. Energy and alcohol prices were set at various levels to characterize alternative energy price levels. Under these conditions, alcohol was produced competitively in all regions for local consumption at wholesale prices ranging from Cr\$2.43 to Cr\$2.55 per litre, or roughly double free market wholesale gasoline prices. Distant markets could be supplied at higher energy prices only.

TABLE 1: Breakeven Alcohol Wholesale Price Levels  
by Production and Consumption Regions a/

Production Regions	Consumption Centres			
	Campinas	Sao Paulo	Itajai	Porto Alegre
	(Cr\$ per litre)			
Campinas (Region 1)	2.43	2.65	3.73	4.55
Santa Catarina North (Region 2)	3.49	3.32	2.45	3.08
Santa Catarina South (Region 3)	3.75	3.46	2.55	2.65
Rio Grande do Sul (Region 4)	4.18	3.88	2.91	2.44

a/ Shaded area represents prices for consumption centres within or adjacent to production regions.

The imported wholesale cost of gasoline was Cr\$1.20 per litre which was equivalent to approximately U.S. \$0.43 per gallon.

Family farm labour is an abundant resource in many small farm regions of Brazil. Energy crops are labour intensive, and their relative profitability is strongly dependent on the value assigned to the family labour input. Part of the analysis focused on the impact of variable costs on competitive alcohol prices. Family labour costs were set at various levels to evaluate this impact. No changes occurred for alcohol prices and resource allocation within the Campinas model. However, within the Santa Catarina and Rio Grande do Sul labour surplus area models, alcohol prices were sensitive to labour costs. A reduction of one cruzeiro per hour in family labour cost resulted in a reduction of about Cr\$.18 per litre for breakeven prices for alcohol in Santa Catarina and Cr\$.08 in Rio Grande do Sul.

In the model, energy crop activities competed directly with other activities for the use of land and labour. An increase in alcohol production, therefore, could occur only with activity substitution at the farm level. The activities most affected were cattle and maize production. Labour use also increased because the energy producing crops are more labour intensive than most of the activities replaced. Energy price increases reduced mechanization in favour of non-mechanized activities.

The general economic interpretations of these results are as follows. First, with present world petroleum prices, alcohol cannot be produced competitively. However, alcohol production is competitive at the energy prices now existing in Brazil and within present price estimates for other alternatives to petroleum (coal liquefaction and shale oil). Within the agricultural sector, regional production centres, labour surplus areas, and alternative source crops are all competitive with centrally located major sugarcane production areas. While increased energy prices reduce agricultural income through increased input costs, energy crop production more than offsets this loss, resulting in a net aggregate gain for agricultural income especially in nonmechanized areas. Employment in agriculture also shows net gains with energy crop production.

#### Implications for Brazil

Brazil's current energy situation—a lack of fossil energy resources, a liquid fuel based transportation system, and foreign exchange problems caused by high petroleum imports—has forced it to make early decisions about liquid fuel use and source of supply. The decision has been made to continue high use of liquid fuels and to produce a significant portion of these in the form of alcohol from biomass. The results of this analysis in some measure support this decision and point to some development steps that will facilitate this change.

The competitive price analysis demonstrates that, while subsidies are necessary to stimulate alcohol production at the present time, a projected two to threefold increase in real petroleum prices within a few years will place alcohol in a competitive range using present technology. Any improvements in production or processing technology will enhance this comparison.

The competitive nature of regional production areas opens up the possibility of spreading the employment and income generating impacts of the alcohol plan more broadly throughout the country. In fact, from the income and employment perspective, needs are greater and gains more apparent when alcohol is produced in regional rather than central areas.

Finally, since this is a pioneering effort, policy planners, technical personnel, and industries have little experience on which to base decisions. Technical developments are also at early levels in some areas such as miniplant design, processing techniques, and energy crop production development. Each of these areas must receive adequate research support if the plan is to move ahead at an efficient level.

## Implications for Developing Countries

Many developing countries have resource situations similar to Brazil. As noted earlier, most developing countries are located in tropical areas with the physical environment to produce significant biomass yields. A surplus labour situation on small farms is also a common characteristic of developing areas. Finally, most tropical countries are fossil fuel poor since the principal coal and oil deposits are located in temperate areas. There are significant differences among developing countries in the relative availability of land for nonfood uses. However, since the model used in this study forced energy crops to compete with food crops for a fixed land resource, the results should be meaningful for land short countries as well.

The implications of the results for developing countries take several forms, including competitive alcohol price levels and labour employment and income generation possibilities. For example, tropical, low income, labour surplus countries may have a comparative advantage in biomass energy production using sugarcane and cassava as raw products. Both are labour intensive, and, combined with a lower opportunity cost for farm family labour, this will allow developing countries to produce alcohol at lower prices. This alcohol may be used for domestic energy needs, or in exceptional cases, exported. In either case, it will substitute for petroleum imports. In addition, a domestic alcohol programme can provide expanded job opportunities in both agriculture and industry, leading to increased incomes.

There is, however, a very important food energy tradeoff to be considered by developing countries. This is especially true in situations where land resources are limited. This tradeoff will be determined in part by the relative productivity and price of energy and food crops. Sugar production may be one of the first crops affected as energy prices rise and alcohol production becomes a plausible option for sugar producing countries. Sugar prices will possibly follow the path of energy price increases as alcohol becomes competitive with other energy sources. In the longer run, other sources (like cassava) may become preferred options even in the sugar producing countries, and thereby reduce the competition between alcohol and sugar.

### RAPPORTEUR'S REPORT—John P. McInerney

A dominant theme in the discussion was the basic economic viability of energy from biomass, it being suggested that the more conventional fuel sources would in general be consistently cheaper over the long term. For example, the breakeven price necessary to make oil shale extraction competitive has consistently risen so that it still remains just uneconomic, and the same is likely to happen with alcohol production.

The potential economics of producing alcohol as demonstrated in the paper were questioned as being specific to Brazil which, as an energy deficit country, has established an artificially high domestic price for alcohol; thus, if opportunity costs (as reflected on the world market) for inputs and outputs had been used, the conclusions would have been both different and more correct. The view was expressed, however, that for certain isolated and small country situations (Papua-New Guinea and Samoa were cited as examples) which could not justify high capital costs of petroleum refining, the smaller scale possibilities of producing energy from biomass represented a valuable economic alternative, and this was where its future probably lay.

Contributing to the discussion were Graham F. Donaldsen, James B. Fitch, Robert C. Kramer, and Alfred Thieme.