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AN EVALUATION OF THE STRUCTURAL AND ECONOMIC EFFECTS OF THE PROALCOOL PROGRAM IN NORTHEAST BRAZIL: A DISSERTATION PROPOSAL

COLLEGE OF AGRICULTURE
The University of Arizona
Tucson, Arizona 85721

AN EVALUATION OF THE STRUCTURAL AND ECONOMIC EFFECTS OF THE PROALCOOL PROGRAM IN NORTHEAST BRAZIL: A DISSERTATION PROPOSAL

by

Zalman Gordin

Working Paper No. 11

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Preface

The papers included in this series* are a result of a collaborative research agreement between the University of Arizona, the Bank of Northeast Brazil, and the Federal University of Ceará. The project, which began in September 1980, is entitled, "Economic and Technical Aspects of Energy Production from the Agricultural Sector in Northeast Brazil. Support for participation by the University of Arizona is provided by the Office of International Cooperation and Development of the U.S. Department of Agriculture. The Brazilian National Research Council (CNPq) is supporting part of the work undertaken by the Federal University of Ceará.

A limited number of these papers are being distributed to researchers and others interested in the economic and technical aspects of energy and agriculture. Working Papers are being published in the language of the authors: English or Portuguese. Contents of the papers represent the opinions and analyses of the authors, not the agencies in which they are employed. Most of the papers in this series are preliminary in nature and are subject to revision. It is expected that some of the papers will be revised and subsequently published as journal articles, monographs, etc. Inquiries and comments should be addressed to:

Dr. Roger Fox
Dept. of Agricultural Economics
University of Arizona
Tucson, Arizona 85721
U.S.A.

Dr. Paulo Roberto Silva
BNB/ETENE
Caixa Postal, 628
60.000 Fortaleza-Ceará
BRASIL

Dr. Jose Valdeci Biserra
UFC/CCA/DEA
Caixa Postal, 354
60.000 Fortaleza-Ceará
BRASIL

*Other paper in the series is: "Net Energy Analyses of Alcohol Production from Sugarcane in the Cariri Region of Ceará, Brazil" by Ahmed Saeed Khan and Roger Fox, Working Paper No. 10, July 1981.

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I INTRODUCTION

Brazil's Economic Growth and Energy

Brazil's economy during the past four decades has been characterized by rapid growth. In an effort to accelerate industrialization, the agricultural sector has supplied most parts of the capital needed for this industrialization process.

Brazil's agricultural sector is continually trying to reach self-sufficiency in food supply. Special emphasis has been given to the expansion and diversification of the sector's export and energy production, in an aim to improve the country's balance of payments and its import capability. Thus the agricultural sector plays a crucial part in Brazil's rapid economic growth.

Brazil has also turned to agriculture to find an alternative source of energy for its needs. Brazilian industry developed using oil as its primary energy source. With the energy crisis in the early seventies, the price of oil increased dramatically. Brazil, which imports about 90% of its oil, was forced to rapidly develop internal source of energy, and turned to biomass in particular--a resource that is abundant in Brazil.

Because Brazil's major economic policies have remained basically unchanged since 1950, futhermore, there is a significant amount of data for throughly studying its policies and performance. A firm basis exists now to construct a comprehensive policy evaluation model, which will be based on an economic unit that is <u>real</u> and <u>large</u>.

The Brazilian federal government serves as economic coordinator in the production and distribution of food and services. How the government implements its policies has significant effects, both short- and long-term, on regional as well as national economic structures, and ultimately on producer and consumer welfare at all levels.

The importance of a study of this nature stems from its possible contribution to our understanding of the behavior of the agricultural sector under changing economic policies, especially in low income countries. In low income countries, the agricultural sector is usually large in terms of population with most, if not all, the income of farmers generated by cultivating subsistence crops. The vast majority of the urban population are in the lower income classes. As a result, almost the entire population in low income countries is highly sensitive to fluctuations in the supply and prices of basic food stuff and energy. The sensitivity of the low income segment of the population to changes in energy prices can be explained by the high correlation between food costs and energy prices because the transportation and services components of food prices includes a substantial energy component. This is true with respect to food prices in the urban centers, as well as for the farmers' share. Even for basic subsistence, transportation of food stuff, and to some degree its processing (rice and mandioca), constitutes a significant part of the final consumer price. Therefore, the ability to study the effects of economic policies on food and energy production, resources allocation, and income distribution, is of great importance.

The ability to measure, evaluate, and compare qualitatively the effects of various economic policies in a given environment, in advance and with accuracy, is the key for sound policy decision making.

The northeastern region of Brazil is especially favorable for implementing large programs of energy production through cultivation of biomass. This region contains ample unused land suitable for energy crops, a sizeable underemployed labor force, and suitable climate, except for periodic droughts. For these reasons, in the Proalcool Program which was implemented by the government in 1975, this region will have major importance. Because of its large scale, the Proalcool Program will surely have profound effects upon Brazil in the areas of resource allocation, income generation and distribution, and ultimately population welfare.

For many countries and regions, especially those already committed to implementing large-scale programs of energy production from biomass, it is important to assess government policies: do they attain the objectives already defined, and what are their short-and-long-term effects. Numerous large industrial and agricultural development programs implemented in the developing countries have met with little or no success, and sometimes even negative results were obtained as a consequence of unbalanced and poorly evaluated programs.

Review of Literature

Brazil's economic development during the last four decades; the role of the central government in the economic arena, especially after the revolution of 1964; the economic model that was developed; the policies that were implemented--these topics have all been recently subjected to extensive research and writing for several reasons. The size, potential, and diversity of the Brazilian economy make it a worthwhile source of study. Brazilian economic models have been in effect long enough to have results that can be evaluated. Numerous development agencies and educational institutions exist. The existence of these agencies combined with today's advanced data processing technology provides the conditions necessary for comprehensive studies of economic units of large magnitude at a relatively low cost.

The role of the agricultural sector is of special interest, and particularly in the Northeastern region. The agricultural sector has provided a significant part of the capital needed to maintain the acclerated industrialization policies that Brazil has implemented during the last four decades. The sector has contributed to the country's balance of payments in recent years by expanding and diversifying agricultural exports, by reducing imports of basic food stuff, and by reducing the need for energy imports. The northeast agricultural sector has been relatively successful in carrying out Brazil's central government policy of being self-sufficient in its energy needs, and to maintain low prices in both areas.

The northeastern region is particularly worthy of study. There, according to 1970 figures, the agriculture sector and related industries constitute approximately 73% of the economically active portion of the population (Leite). According to the same study, constant net outflow of capital from this region to the southern regions is evident. This analysis implies that the northeastern region is a constant supplier of capital, though not the only source, to other regions and industries. Especially as regards energy production, this region's special physical and economic characteristics seem to imply a high sensitivity to changes in government's economic policies.

Paiva, Barbosa, and others have characterized the economic policy pursued by the Brazilian economic authorities since World War II as one of import substitution and self-sufficiency. This major policy line has not been altered through the years, even while major changes in the economy's structure and the role of the central government have taken place, especially during the last sixteen years.

For example, during the period 1950-1978, the economic system transformation was marked by the change in the central government's role: from decentralized economy, where the central government functioned loosely as economic coordinator, to a highly centralized controlled economy, where the central government had complete or almost complete control over some of the major industries--banking, energy, mining, and transportation. More recently these policies are being gradually substituted by decentralization, especially in the banking, mining, and transportation industries, and partly in the energy production sector.

Another important economic structural change which took place in the past ten years was the rapid development of the securities market. This market plays an important role in stimulating and directing capital savings and investments (internal and external capital). In addition, the central government in recent years has shifted from fiscal to monetary policies; the economic authorities are directing the economy more and more via the money market.

The economic objectives set by the planners of the Brazilian economy from the fifties through the seventies has been summarized by various writers as follows:

(a) Substitute Brazilian goods for imported industrial goods, and become self-sufficient in food and other agricultural products.

(b) Accelerate industrialization in order to cope with the rapidly increasing labor force within urban centers, which has resulted from migration from rural to urban areas.

(c) Accelerate economic growth in order to improve the population's welfare.

(d) Become self-sufficient in supplying energy needs, if possible, on a regional level.

The agriculture sector has been expected to meet the above objectives without substantial government support. It was expected to attain self-sufficiency of food supplies at the lowest prices possible, to supply much of the capital for the accelerated industrialization process, and to absorb most of the rapidly increasing labor force.

Since the end of the sixties, and particularly at the beginning of the seventies, the agricultural sector has been expected to increase and diversify its exports and reduce energy imports to offset the increasing balance of payments deficit caused by soaring import oil prices and to maintain the country's import capability, a necessary condition for maintaining economic growth.

Barbosa, Carneiro and Nicholas, in their analysis of agricultural sector performance during the last three decades, approach the question from the point of view of objectives attained; that is, whether the central or regional governments have succeeded in reaching stated objectives.

Many attempts have been made to determine whether different policies or sets of policies within the agricultural sector result in better performance, and whether some policies achieve the same results with less expense. The question of policy efficiency remains a matter of opinion and not a subject of comparable quantitative analysis. Most of the studies on the subject of agricultural policy efficiency, especially in low income countries, are essentially descriptive historical analyses. Few comprehensive quantitative analyses of the subject using a single product or group of related products have been published, and even those published usually fall short of policy evaluation.

Few studies have addressed the task of evaluating the allocative effects of policies on regional resources and incomes.

A research report published by a team at Ohio State University attempted to relate and explain farm growth and farmers' response to changes in market conditions and government policies. The study's findings and conclusions were based on the Brazilian program to expand wheat and soybeans production as part of its general policy of import substitution and food self-sufficiency. The study investigated two agricultural products that are concentrated in the southern part of the country because of its climate. Both products are produced mainly by large farms. Because most of Brazil's rural population is located in the central and northern parts of the country, neither of which depend on, nor produce those products, it is questionable if the study's findings and conclusions apply to major energy crops in Brazil or other low income countries, particularly with respect to alcohol production in the northeast, where mandioca may become the main energy crop.

In reviewing recently published literature related to problems of energy supply and demand, both worldwide and for Brazil in particular, several well known questions have surfaced.

1. The problem of supplying energy is by no means unique to the industrial world. This problem is probably more severe in the developing countries, and particularly in Brazil. The present situation, and the increasing competition for energy supply, suggests that internal solutions are required to solve Brazil's energy supply, even in the short run.

2. Conventional forms of energy that energy-deficient countries import can be characterized in general as nonrenewable resources, geographically concentrated within the boundaries of a small number of countries. For example, oil and gas resources are located in the OPEC countries, the United States, and the USSR, and about 80% of the world's coal resources are located in the United States, the USSR, and China.

3. Nonconventional sources of energy such as solar and nuclear energy, as well as more conventional forms such as oil shale and synthetic fuels, are not expected to become important substitutes for gaseous and

liquid fuels before the beginning of the next century. Even then the extent of substitution is not clear.

4. Hydropower, solar, and nuclear energy sources, which now are basically used in the form of electricity, will not constitute a complete substitution for more conventional energy sources before major technical development has been achieved in transportation and other industries. These sources of energy are also to a certain extent geographically concentrated, with the exception of solar energy, and nontransactional on the world markets because they are used in the form of electricity. Finally, the availability of these sources depends upon ore reserves (nuclear) and upon national water resources and topographical formation (hydropower).

5. The general consensus among researchers is that biomass is the only source that now can substitute physically, and also is economically feasible for conventional energy sources: oil and coal. Furthermore, it is probably the only major source of energy available to most of the developing countries. Even if it is used as a partial substitute for other energy sources biomass production will help alleviate the severity of many economic problems such as balance of payment, unemployment, income distribution and level, and perhaps even rural migration problems.

Biomass as a source of energy has limitations, both now and in the future. These limitations may lessen with the development of new technologies; nevertheless, predicting the prospects of biomass development at this time is clearly difficult. The uses of biomass for energy differ greatly between countries at present. Because prospects of available energy are bleak, most countries, developing and industrial, have increasingly turned to renewable sources of energy. France, Japan, the United States, and

Brazil, for example, are allocating increasing amounts of resources for biomass through energy conversion technologies, development, and production.

Estimates of arable land available on our planet for food and energy production amount to approximately 3.4 billion hectares (1.3 billion hectares are now in use). According to various estimates, this land will be capable of supporting between eight and thirteen billion inhabitants, and will allow for energy production as well. This estimate does not include the possibility of energy production from oceanic and other water biomasses (39).

Present limitations on biomass as a source of energy result from low efficiency during solar energy conversion of green plants, whose range lies between 1% and 3.3%. Improving the rate of solar energy conversion will to a certain extent reduce competition for land by food and energy producers. Such competition currently exist to various degrees in different countries and in different regions. In any event, biomass, a renewable resource, will play an increasing role in solving the world's energy supply problem.

The amount of competition between food and energy production seems to vary greatly among developing countries. Even in the most populous countries (such as China and India), a sizeable portion of the land and the labor is either unused or very extensively used. This variant may affect food and energy resources competition in the long run. In less populous regions, such as northeastern Brazil and other Latin American countries, competition between food and energy resources is probably questionable, even in the short run, in spite of the present state of technology.

Biomass as a source of energy has several apparent advantages, especially for less developed countries:

1. Energy sources will not be geographically concentrated within political boundaries.
2. Simple methods exist for converting biomass prime material to the presently used forms of energy. These conversion methods are relatively easy to adopt by any country, even at current levels of skilled and professional labor forces within these countries.
3. For less developed and less populous countries, energy production from biomass provides the possibility (probably at lower opportunity costs) of better use of their ample labor and land resources in the agricultural sector, which in those countries is the most populated sector.
4. As an internal energy supply solution, biomass energy can provide a new source of income and can reduce risks for the agricultural sector in any country, with or without existing competition between energy and food production.

For many countries and regions, especially those already committed to implementing large-scale programs of energy production from biomass sources, there are important questions to be answered. As stated before, a close look at programs and policies is important when we see the poor rate of success of many large industrial and agricultural development programs in developing countries. Sometimes even negative results have resulted from unbalanced and poorly evaluated programs. From various studies cited, it is apparent that various programs and policies implemented by the Brazilian government during the past four decades did not succeed in attaining their planners' prime objectives os self-sufficiency in food and stable prices. Furthermore, despite substantial efforts, incomes of the rural and urban population rose only moderately. In fact, some writers (23, 37) argue that incomes of the rural population declined substantially in recent years. Low-and medium-income groups did not fare any better: prices were constantly rising, the supply of basic food products fluctuated widely, and frequently shortages occurred. The irrigation program implemented by the Brazilian Central government in the northeastern region is an example of resources misallocation and of negative economic returns on a large scale and at enormous social cost (de Melo 1980a, Hall 1978).

Several recently published studies (31,28,A-14) about biomass energy production have indicated that the northeastern region of Brazil would be an economically ideal location for implementing large-scale production programs. These studies cite the existence of ample unused arable land suitable for energy crops, and not suitable at the present state of agricultural technology, for food crops. They also show that in the northeast a sizeable unemployed labor force exists (Scandizzo and Leite). Recent studies estimate that half of the economically active labor force work only 61 days per year; the other half work during certain seasons and are otherwise unemployed. In short, the labor force is being used at about half the capacity that is possible.

In this region production of energy crops is more stable (yield in hectares per year) compared to other regions. The opposite is true with respect to food crops (Pasqual and de Melo). In addition, solar radiation, which is a prime factor in biomass production, is higher in the northeast than in the southern part of Brazil, its level in the northeast averaging 2,100-2,300 light hours per year. Climate conditions in the northeast favor perennial crops rather than short-period crops because they produce probably more stable yield per unit of land. Finally, lower opportunity costs of land and labor compared to other regions may compensate for low soil fertility; therefore, from a national standpoint, the overall cost of energy production from biomass in the northeastern region may be lower than the costs of production in other regions, and may be more competitive with other sources of energy.

When the Brazilian government enacted the Proalcohol Program in 1975, the location of production in the central-south was developed in the southern region for the following reasons: (a) existing idle capacity of alcohol production plants in the sugar production region (zones), (b) existing large scale sugarcane plantations, ideal for alcohol production, in the southern regions, (c) necessity for a stabilization tool for the Brazilian sugar industry, which is susceptible to a volatile world market. Any expansion of this industry will have to be stretched out to other regions and subregions, by introducing other crops besides sugarcane, by investing in new processing plants, and by incorporating new land.

These studies (2,4,9,27), which are concerned with a variety of biomass energy production problems in the southern regions, have been assumed to be conceptually and technically applicable to the northern regions. Nevertheless, because there are substantial structural differences between the northern and southern regions, similar studies regarding the northern region would probably arrive at different conclusions.

The present economic inferiority of the northeastern region of Brazil can indeed change if its biomass energy production potential is tapped. Brazil's regions would each specialize in various amounts of food and energy production. As for efficiency studies in economic policy implementation, a new approach is needed. Not the traditional, descriptive historical treatment, but rather a quantitative dynamic approach that will compare sets of policies in a particular economic environment. This dynamic approach provides a sound basis for both formulating and evaluating economic policy.

Statement of the Problem

This study proposes to identify and evaluate the long-run allocative effects of the Proalcohol Program on the northern region's economic structure by evaluating quantitatively some proposed and implemented policies. The Proalcohol Program, if implemented on the large scale that is planned will have profound structural and economical effects on Brazil's agricultural sector, particularly in the northeast. In order to fully appreciate the dimension of the problem, we can calculate the resources reallocation required for some basic agricultural products to achieve program objectives, then compare those with the actual resources allocated.

To produce 10 billion liters of alcohol requires 3.5 million hectares of sugarcane at full production (1.4 million hectares are harvested at present). If alcohol production continues to be based primarily on sugarcane and if no new land is incorporated, certain tradeoffs will be necessary (de Melo 1980a,b). According to some estimates, these reductions mean the production substitution amount to about 500,000 to 600,000 metric tons of dry beans, 1.5 to 1.7 million tons of rice, plus the same amount of corn. These reductions amount to approximately 20% of dry beans, 8% of rice, and 9-10% of corn production in Brazil. Furthermore, assuming that these crops produced less efficiently in the northern than in the southern regions, and that sugarcane production stays at the same level, then for the same amount of alcohol produced, the relative substitution effect in the northeastern region will be larger.

If mandioca becomes the major source of alcohol production in the northeast, then new lands can be incorporated into the production process. But the magnitude of crop substitution is not clear since in general mandioca is associated with corn and beans and is produced on small farms. Therefore, it is not clear to what extent those crops are substitutes or complements.

It is obvious that the Proalcohol Program will result in major changes in all sectors. The direction and magnitude of these structural-economic changes, the costs involved, and the efficiency of policies implemented within the framework of the northeast--these are the problems to be investigated.

The problem as stated above will be methodically and technically divided into three subproblems, which can be solved sequentially. These subproblems are enumerated below:

1. Identify the system (the northeastern region), the variables (exogenous and endogenous), and their relationship. In this way, we can construct the system's dynamic association with government policies from 1950 to 1980 and thereby predict future systems performance.
2. Construct a system model and validate it. To validate the model we can compare predictions and estimates of the model with observed system values in Brazil for the year 1980.
3. Project future performance under different policies. Various policies to achieve the alcohol program's objectives will be studied, then compared with alternative policies. One alternative policy studied will be the absence of any government intervention in the process.

The phrase <u>system performance</u> refers to the changes in the allocation and distribution of resources between sectors (agriculture, industry, and services) and subsectors (energy crops, grain crops, and government services). System performance will be discussed in both quantitative and qualitative terms; it will be viewed in the framework of labor and land uses, capital investment, and income level and distribution.

Objective of the Study

The basic objective of this study is to evaluate the economic and structural effects of the <u>Proalcohol Program</u> by comparing Brazil's present economic system, which is based on strong government intervention, with the free market system. Evaluation of the economic effects of the <u>Proalcohol Program</u> in the environment of a "free market system," that is with no government intervention in the economic system's performance, is important for various reasons. By modeling the two systems and comparing them, we can estimate the benefits and costs (harm) of government intervention in a concrete, methodical manner. Since the recent trend of the Brazilian government policies is toward less intervention, these systems need to be studied. Many observers feel that the Proalcohol Program as it is now structured will actually have a negative social benefit: cost ratio, and that relying on market forces will solve Brazil's energy and food supply problems more efficiently in the long run.

This evaluation will be made by first evaluating possible future resource allocations and structural changes under different sets of policies, then comparing costs and benefits of the program under different economic environments. In both cases the comparison will take into account the ultimate objective set by the Brazilian Central Government, that of regional self-sufficiency in energy. The study will concentrate on the regional level, without reference to subregions or states. It will contain submodels for the food, energy and nonagricultural production sectors. By selecting the regional level, we can build a base for macroeconomic policies, and indirectly we can compare economic systems of high government interventions and no government intervention in the production process.

From the point of view of practical policy implementation, quantitative evaluation of segments of the Brazilian economic experience has great appeal. In spite of this, many low income countries fail to use existing quantitative tools in formulating agricultural economic policy. This study proposes to concentrate on program implementation now occurring in Brazil, at a level of aggregation that will reduce the complexity of the chosen model.

As de Hean points out:

> The use and application of quantitative models, in the process of agricultural decision making has always been controversial. Models had been characterized by lacking an empirical foundations and excluding relevant facts. . .On the other hand, there is growing demand of agricultural policies agencies in many countries to evaluate costs and benefits of alternative policies measured quantitatively, (pp. 299-312).

The advantage of a quantitative economic model lies in its ability to predict reasonably well future development by looking at past behavior of the economic unit in study. This approach requires an understanding of the relationships between the <u>factors</u> in the system, and the ability to give these factors quantitative measurements. The direction that policy impact will take is important to know, but comparison between alternative policies in a dynamic environment can be evaluated correctly only by quantitative measurements.

Those who formulate policy must understand the system they live in and know its parameters. They need tools to assess whether the policies they recommend will be successful. That is the basis for rational policy decision making. By basing this study on the policies implemented from 1950 to 1980 in Brazil, it will be possible to construct a simulation model. In this way, past, present, and future policies can be evaluated accurately. The model suggested here will be basically an extension of the simulation model for the U. S. agricultural sector, and will be used to study the economic environment of northeastern Brazil. As in many developing countries the agricultural sector in the northeast is composed of a monopolistic input market and an oligopsonistic output market. In both of the above cases, agricultural output is used either as a final product or as an intermediate input commodity. These noncompetitive characteristics must be incorporated into our model in order to adequately describe the system's performance.

The proposed simulation model will be composed of two principle units:

1. Simulation of present system performance. The model will be validated by comparing estimated values of the model variables with observed values for the year 1980.
2. Projection for the years 1981 to 1990. A projection simulation model will estimate the structural and allocative changes that result from different policies, all with the same goal of energy resource substitution. This problem will be approached through a regional framework.

II. RESEARCH METHODOLOGY

To construct an econometric model, relevant variables and relationships (equations) depend on the level of aggregation chosen and on the objectives of the study. The objectives of the study and the level of aggregation have been stated previously. The selection of variables for our system is based largely on theories concerning the behavior of the economy as a whole (in our case the northeastern region as a homogenous unit). We are concerned with questions such as the following: Why is macroeconomic activity at a given level? How can this level be raised or lowered? What determines the growth rate of the region's major resources? What is their potential output, as well as their level of utilization?

In the course of constructing our model, we must question the use of the static theory of the competitive firm as a basis for explaining aggregate behavior in agriculture. Contrary to operating in a perfectly competitive market, the agricultural industry in the northeastern region of Brazil is believed to have monopolistic-monopsonistic elements. Therefore, as we look at energy production from biomass, since the resources will be concentrated in the northeast, our model must address this theoretical structural question.

Static macroeconomic theory presupposes that the economy will adjust instantaneously to any change in the economic environment (price changes, etc.); the economy is assumed to be continuously in a state of equilibrium. In reality, full resources adjustment in response to a change in an exogenous factor of the system takes time. Furthermore, a change in a given exogenous variable (factor) may affect endogenous variables of the economic system in different ways (in terms of time interval). Those effects that we measure by elasticities may even have different values for a given endogenous variable in the long or the short run. As a result, full resources adjustment may spread over several periods of time. Since the system's exogenous variables are always changing, the system will probably never be in equilibrium, but within each period the system will strive toward a new equilibrium (7,25,33). The model proposed here needs to capture the magnitude of the adjustment factor, which represents both the velocity and the direction of the adjustment process. Another aspect of the region's economy that this study must address is that, in any industry, the price structure for resources depends upon supply and demand; in Brazil, however, and in the northeastern region in particular, government intervention has resulted in a noncompetitive agricultural industry structure. It has exercised control through subsidies, price controls, wage fixing, and regulation of resource supplies. The effect of strict government intervention must certainly be reflected in the analytical model.

Hypotheses

Three hypotheses have been advanced about certain aspects of the Proalcohol Program's long-run effects on the region's economic structure and use of resources:

Hypothesis 1. If the present policy of price determination, fiscal incentives, etc., continues, ownership of resources will become concentrated in the agricultural sector, and income distribution will become increasingly inequitable as compared to a free market system.

Hypothesis 2. Applying free market policies to the problem of supplying and pricing of energy will result in a more efficient allocation of resources.

Hypothesis 3. Looking at present regional resources, such as land, labor, energy, water, and capital, it is doubtful that competition between production of energy sources and food supplies will exist in the long run. In the short run, some internal regional adjustments may have to be made, but, in the long run, biomass energy production in the northeastern region will use mainly incorporated unused resources, primarily land and labor. In this way, biomass production will increase economic efficiency of resources now being used, such as capital, water, land, and labor. With the type of technology now used in the agricultural sector and present availability of water, much land is not suitable for food production, but is suitable for such energy crops as mandioca and wood.

Limitations

Because of the complexity of the problem, the level of aggregation, and the reliability of data, a study of this nature has some obvious limitations:

(a) This study does not attempt to analyze the problem from a microeconomic level. Data at the farm level are scarce and often unreliable. For crops such as sugarcane, which is produced primarily by large producers, data exist. The same is not true for mandioca and other food crops, which are produced mainly by small farmers. Data published by various institutions on costs and returns at the farm level vary widely. Aggregation will alleviate the problem, but may also result in some loss of information about the sensitivity of the submodels within regions.

(b) Since data on costs and returns used to construct submodels are difficult to verify, their effect on simulation results is unknown. This problem needs to be solved in the course of the study.

(c) Certain variables, such as weather and rainfall distribution, might improve the model, but for technical and budgetary reasons will not be included.

(d) Because this study is concerned with the effects of the Proalcohol Program from a regional point of view, the northeast in particular, the effect on other regions of changes in the program will be aggregated in the unexplained portion of each dependent variable studied. Especially in the case of energy production, where extreme regional specialization exists, a policy change in agricultural production might show greater effects in the southern region than in the northeast.

(e) For our predictive modeling purposes, world prices of energy and of both agricultural and nonagricultural inputs will reflect the pattern of prices for the period from 1973 to 1980, even though this pattern may not prove to be repeated in the future. Growth rates of population and food production trends will also be assumed to follow the pattern of that same period.

(f) This study is based on time series data for the period from 1950 to 1980, and will consist of thirty observations, one for each year. Statistical problems may be encountered relating to the significance of some of variables' effects.

Assumptions

(a) It is assumed that the Proalcohol Program will continue from 1980 to 1990 with objectives and resources that are no different from the present ones.

(b) The study assumes that farmers are highly responsive to price and policy changes, regardless of the size of the farm. Fluctuations in biomass and alcohol production are assumed to result from changes in area planted, and not from changes in other inputs. No changes in production technology for biomass or alcohol during 1980-1990 is assumed. Supply of biomass, with simple storage techniques, is assumed to be relatively price elastic, even in the short run.

(c) Given the importance attached to alcohol as a possible substitute for oil, it is assumed that the demand for biomass will continue to grow at least at the present rate for the next decade. Since the demand for energy is relatively price inelastic, prices will be assumed to be rising during the same period.

(d) Because no differences exist between subregions with respect to biomass production (especially mandioca), subregional data is assumed to be representative for the region as a whole, and vice versa.

(e) No significant changes in energy supply by nonconventional sources is assumed. The world supply of oil will be assumed to be at the current level, with increasing price.

(f) Supply of water for regional agricultural uses is assumed fixed at the current level; that is, regional fixed irrigation capacity is a limiting factor.

(g) The population growth rate is assumed to remain at current level; a persisting high level of unemployment is assumed.

Some Dynamic Aspects of the Model

The proposed model will study directions and changes in the economic structure of the northeastern region of Brazil. When we speak of a dynamic system, we refer to the pattern of change through time in the values of endogenous variables. A system may be seen as dynamic even when there are no changes in the economic structure of exogenous variables; that is, no changes in behavior patterns or institutional, technical, or policy changes.

The term dynamic-static refers to the comparison of two static equilibria in the economic system at different times. We speak of changes in endogenous variables as a result of changes in one or more exogenous variables. To measure rates of change for discrete units of time (for example, years), the best measure will be $dX_t = X_t - X_{t-1}$. Difference equations are appropriate tools even though time is continuous rather than discrete, so using difference equations as variables is the same as using lagged variables; that is, variables pertaining to previous time periods.

The dynamics of a system is concerned with the path that the economic system takes through time from one static equilibrium to another as a result of changes in some parameters or exogenous variables. Any dynamic model generates a time path of its variables determined by the model, by the numerical values of its parameters, and by the initial endogenous variables (initial conditions). All these variables, determined in advance for each period of time (t), are predetermined. From those predetermined variables, the system determines its endogenous, or current, variables.

The reduced form for a system of difference equations results from solving the system for each of the current endogenous variables in terms of predetermined variables and parameters. Thus, the reduced form of a system of difference equations expresses the time path of the endogenous variable, step by step; the original set does not. The reduced-form equation need not give the time path of each endogenous variable in terms of exogenous variables and lagged endogenous variables. Therefore, when the reduced form is further transformed so that each endogenous variable is expressed only in terms of exogenous and predetermined variables, the result is the final solution.

The simple dynamic model and its solution describes the corresponding static system's adjustment to an initial equilibrium. Given the time data that the endogenous variables follow in moving from one static equilibrium to another, and given the changing exogenous variables and parameters, we can trace the movement of the system through time.

Often in dynamic modeling, it is plausable to assume that current values of one variable depend on many lagged values of other variables: in practice, a generally-distributed lagged function in linear form is easier to work with and is often assumed where the coefficients of the distributed lag decline geometrically. Distributed lags are useful whenever there is a process of gradual adjustment to change.

Another aspect of any dynamic model is the concept of causation. Simply stated, causation is where one particular event, the cause, is always accompanied by another particular event, the effect. In this study we will use the concept of causation and combine it with the dynamic system idea of specific external causes, the exogenous variables of the system. For example, our model may be seen (Ray) as a system of G equations with G endogenous variables, $Y_1,\ldots,Y_G$; with lag forms, $t-1,\ldots,t-T$, where T is the order of the system; k exogenous variables, $Z_1,\ldots,Z_K$; and α represents the number of system parameters. Here is the model:

$$f_1\left[Y_1,\ldots,Y_G;\ (Y_t)_{-1}\ldots(Y_G)_{-1};\ \ldots(Y_1)_{-\tau};\ Z_1\ldots Z_{Kj}\alpha_{i1}\ldots\alpha_i \right] = 0.$$

for $i = 1,\ldots,G$.

The above equation will have a unique reduced-form solution in terms of predetermined variables, exogenous variables, and system parameters.

If a sufficient number of initial conditions are given, and the values of the exogenous variables and parameters are given, the system will generate values of endogenous variables for all succeeding periods into the indefinite future. The reduced form describing this may be rewritten as

$$Y_i = G_i \left[(Y_1)_{-1} \ldots (Y_G)_{-1} \ldots (Y_1)_{-\tau} \ldots (Y_G)_{-\tau},\ Z_1 \ldots Z_k,\ \Pi_{i1} \ldots \Pi_{iM} \right] = 0,$$

where Π_{i1} and Π_{iM} are reduced-form parameters depending on the α-value, and i goes from 1 to G.

The final equation system may be written as

$$Y_i = \left[h_i (Y_i)_{-1} \ldots (Y_i)_{-\omega};\ Z_1 \ldots Z_K;\ Y_{i1} \ldots Y_{iN} \right] = 0, \text{ for } i = 1, \ldots G,$$

where Y_{i1} and Y_{iN} are parameters depending on the value of α and where ω is greater than the order of any of the structural equations or reduced-form equations, and may be as great as the product of G and t.

The question may arise: Why use the dynamic approach and not use comparative static analysis, which analyzes the difference in static positions of a model under alternative sets of values of parameters and exogenous variables by calculating the system's multipliers? Comparative-static multipliers are not very useful in practice unless the system's adjustment process is very fast. Usually exogenous variables in real systems are not held constant for more than short periods (about two years); therefore, any new equilibrium that takes longer to reach will never be reached.

The usefulness of the dynamic model lies in its ability to tell how long it will be before a new equilibrium position will be attained, and to give the effects in each time period. This information is important for policy determination and evaluation. These impact multipliers are presented by Goldberger (1959).

The discussion so far had been related to exact dynamic and static models. When we deal with projection (forecasting), we are dealing with a dynamic-stochastic model, where the effects of stochastic disturbances on the projected values of the system's variables must be accounted for. In the dynamic as well as the static case, predictions based on reduced-form equations will not be exact, even though the underlying structural equations are correct, because of random disturbance. The disturbance factor is a random variable with a probability distribution, such that there is a specified probability that the disturbance factor will fall within any interval we choose. The projected values of endogenous variables becomes more uncertain as the lengh of time increases, even when the exogenous variables and initial endogenous variables are known. Because the values are based on the disturbance in all future periods, some elements of uncertainty will always be part of the final projected value.

Our general model will be in the form previously described, including the stochastic factor. The general linear dynamic stochastic equation system with additive disturbance is

$$\sum_{i=1}^{G} B_{gio} Y_{it} + \sum_{t=1}^{T} \left(\sum_{i=1}^{G} B_{git} Y_{i,t-K} \right) + \sum_{K=1}^{K} E_{gk} X_{kt} = U_{gt} , \quad g=1,\ldots,G,$$

where B_{gio}, B_{git} and E_{gk} are parameters; Y_{it} represents current endogenous variables at time t, and $Y_{i,t-T}$ represents lagged endogenous variables at time t with lag at period τ' $\tau = 1,\ldots T'$ where T is the largest lag in the model. X_{kt} represents exogenous variables at time t; U_{gt} represents disturbances at time t. The other part of the model structure is specified by the joint probability distribution of the disturbances term $U_{it},\ldots,U_{Gt}$, which is often assumed to be normally distributed for all t.

If Z_{xt} denotes all variables, both exogenous (X_{kt}) and lagged endogenous ($Y_{i,t-\tau}$), and γ_{gk} represents parameters of Z_{kt}, and if B_{gi} is used instead of B_{gio}, then the general equation model may be written as

$$\sum_{i=1}^{G} B_{gi} Y_{it} + \sum_{k=1}^{k} \gamma_{gk} Z_{kt} = U_{gt} \text{, for } g=1,\ldots,G.$$

The reduced form is written as

$$Y_{it} = \sum_{k=1}^{k} \Pi_{ik} Z_{kt} + V_{it} \text{ for } i=1,\ldots, G,$$

where $V_{it},\ldots,V_{gt}$ are jointly normally distributed if the V values are normally distributed.

The final equation is obtained as before, thus

$$Y_{it} = \sum_{T=1}^{T_i'} O_{it} Y_{i,t-\tau} + \sum_{K=1}^{K'} \mu_{iK} X_{Kt} + w_{it}, \text{ for } i-1,\ldots,G.$$

where O_{it} and μ_{ik} are parameters, w_{it} represent the disturbance terms, and X_{it} represents the exogenous variables. Each of the final equations is a linear stochastic equation in one variable, similar to the variable in the exact model, which for the projection model is subject to uncertainty.

Another problem arising from the introduction of the stochastic element is that exogenous variables must be redefined. In the model, their values were predetermined at a given period of time (including exogenous and lagged endogenous variables), and were statistically independent of the disturbance for all time periods. But now we cannot have predetermined variables statistically independent of the disturbance terms for all time, since we may be interested in lagged endogenous variables, such as Y_{t-k}, $K > 0$, to be predetermined variables for time t, which is already not independent of U_{t-k}, because $Y_{t=k}$ is determined by the model as a function of U_{t-k}. But it is possible to require that predetermined variables (z_t) be independent of disturbances in current and future periods (Koopmans and Hood). The independence is the basis of the new definition. For a variable to satisfy this definition, it can be either an exogenous variable or a lagged endogenous variable in our model. If exogenous, it is then by definition independent of all past, present, and future values of disturbances. If it is lagged endogenous, then for every period (t) each disturbance (U_t) is statistically independent of all its past values (U_{t-1}, U_{t-2},...) (Christ, 1966). This is one of many reasons for assuming that the disturbance term in the dynamic model is independent of all its own past values.

It is not necessary to assume independence between economic variables themselves over time, because it is practically impossible to build a model with such a restriction. Also, it is not always necessary to assume that at any one time (t) the disturbances in different equations of the model are independent of each other. The assumption usually made is that disturbances of time t are independent of any other group of disturbances in time $t-k$ where k is not equal to zero.

Energy Supply and Price Projections

Some comments are necessary in addressing the question of model supply identities and price equations. The main concern of world energy supply and demand, both now and in the future, is one of resources development and its share in total energy supply, particularly regarding its effect on oil pricing.

One approach to the problem (expressed in a previous section) suggested a shortage of oil in the near future (ten years), higher prices, and slow development of substitute sources of energy. Other analysts have taken the position that there will be a substantial increase of energy supply by nonconventional energy sources and by coal through the eighties. According to a study of world coal resources by M.I.T., coal and nuclear supply is becoming saturated in many countries, along with reduced demand because of conservation. As a result, a decline in prices is assumed (Singer).

Nevertheless, for the purposes of our model, the decision is to take the conservative view of future higher prices for oil as a result of depletion of reserves, higher demand for oil due to increases in population and income, and slow development of oil substitutes as sources of energy.

III. SIMULATION METHODOLOGY

A computer simulation model is founded on a set of mathematical relationships. These relationships represent the function of an economic unit or system (Ray), and enable us to investigate the influence of different components and of time on the overall system.

The simulation program chosen for this study is a powerful analytical tool. It uses a recursive econometrics model to incorporate lagged variables and solve small sets of equations sequentially. Information gathered in a given subset at some period t is used in succeeding subsets at the same period. Then when all the subsets of a system at period t are completed, a description of the system as a whole in time t is given.

Following the above steps, the program starts again, and using the first-period estimated values and additional input information, produces another cycle ($t+1$). Repetition of this process with or without introduction of new variables or changes in the system parameters, produces the time path of the system's variables at the sector level and for the system as a whole. The model provides the researcher information on the impact of any change in variable values (policy changes). This "feedback" characteristic of the simulation model adds realism to the system experiment, and, combined with the linkage between subsectors, gives a powerful tool to evaluate policy's effects at different levels (primary, secondary, etc.). It is assumed that five to ten years are required to trace all direct and indirect influences of a policy (set of variables) change. The importance of this tool is that it can be used to study the system without assuming an instantaneous adjustment mechanism, which is not a real world phenomenon.

Overview of Model for this Study

In this study the northeastern region's economic system is divided into nine subsectors:

(1) Energy crops (sugarcane, mandioca)

(2) Grains (beans, corn, sorghum, rice)

(3) Industrial crops (cotton, sisal, tomatoes, fruits, cashew)

(4) Livestock (pasture, beef, milk and egg products)

(5) Manufacturing and textile industries

(6) Processing industries (food products)

(7) Petro-pharmaceutical industry

(8) Services and commerce (private sector)

(9) Services and commerce (public sector)

These submodels include most of the region's economic system. They are assumed to be casually related to demand for resources, sector commodities production, and prices (resources and commodities). The lags between committing resources and production in the different agricultural and industrial subsectors permit a recursive formulation of the submodels equation sets. At this stage of the study the system's division is assumed to be adequate in order to isolate the effects of the alcohol production program on the system structure.

Today sugarcane and mandioca are produced mainly for food. But since they hold the most promise as biomass sources for future energy production in Brazil, some line must be drawn between the subsectors of energy and food. Other crops, such as corn and sorghum, could have been included in the energy crops submodel, but were selected to be in the grain subsector.

In broad terms, submodels are constructed as follows:

1. The demand for energy resources in a given year depends on the prices of output in the past year, prices of inputs at the current year's production quotas, and prices of oil and other energy resources.

2. The amount of production depends on the supply and demand of available resources, and on the expected output price at the end of the production period.

3. The supply depends on current production, the amount being imported, the carry over from the preceding year, and on current prices.

4. The demand for the commodity depends on current production, the amount being exported, income, the commodity price, and the price of substitutes.

5. Average commodity prices at a given period depend on supply and demand at that period, and on such variables as price supports, subsidies, and taxes.

6. Gross income from the commodity depends on the amount of production during the given period, and on such variables as government payments, taxation, current period prices, and production efficiency.

Links between submodels are set up recursively so that information generated in any one submodel may be used in the remaining submodels. (For example, the energy crop submodel will generate information that may be used in the livestock model and/or in the other remaining submodels.)

Agricultural output, like industrial output, is a function of the level of resources used, the productivity of resources used, and of output prices. Income and resource returns are tied directly or indirectly to resource commitments; therefore, to be able to estimate and understand the effects of policies (changes in exogenous variables) on output, the demand for resources must be known. Changes in price or output in one year, as the result of a given policy (change in given variables), can influence the demand for resources or output in the next year. Also, if a change in one exogenous variable affects one submodel (which in turn affects another submodel, which in turn affects other submodels) there will be changes in resource demand for these submodels. As mentioned before, the model must trace the time pat of the impacts of change in exogenous variables on different endogenous variables studied.

The equations of each submodel are divided into three subsets:

Subset 1. Pre-input equations. These equations contain the relations that explain the level of resources allocated to the submodel's production. For example, an equation may estimate total value of physical assets applied to production of given commodity, or an equation may estimate the amount of land that will be used in a given agricultural submodel.

Subset 2. Input equations. This section in each submodel represents the relations for monoperiod operating inputs, and the flow of services from durable resources. Some examples are fertilizers, labor as operating inputs, and machinery expenses.

Subset 3. Output equations. The first relationship in this section is a production function, such as the Cobb-Douglas one. The form of the production function and the statistical problems involved are discussed later with econometric considerations.

For the second equation of this set, the input demand (estimated from input subset) is fed into the production function to estimate production results, which, combined with past inventories and imports, results in construction of the commodity's (submodel's) supply identity. The submodel (commodity) relation uses as an explanatory variable the difference between current year's supply and the past year's commercial demand. The current year estimates for commercial demand, inventories, and exports depend on the current year's commodity prices and on other variables as well. The final equation in each commodity (submodel) generates the submodel gross income as a function of output, prices, and other variables such as government payments and taxations.

The simulation process starts by reading into the computer the initial values of all predetermined variables not generated within the system. These variables include dependent ones, whose values were already determined within the system, and exogenous variables.

The econometrics equations are then processed sequentially. The first equation of the energy submodel is solved first using the initial data and equation parameter estimates. The generated value is stored, and the second equation of the submodel is estimated. The generated variables estimated are used in succeeding equations. The remaining relations in energy crops pre-input section are solved, and the results are stored sequentially.

The energy crop input equations are treated next, and then the output section of this submodel is processed. Estimates for pre-input, input, and output sectors for all succeeding submodels are then generated. Finally, system estimates (in our case for the northeastern region) are built up from the submodel estimates. When the last regional estimate has been calculated, one period for the northeastern regional economy has been described.

The second period of the analysis starts by returning to the energy crop pre-input section. In the second and succeeding periods of simulation, lagged independent variables values are not read from the given initial data, but from the stored values estimated by the system at previous periods. As many runs are made through the model equations as the analysis determines.

Each run represents a period, in this case, one year. Each year's estimated values demonstrate (by addition and comparison) the time path of the system's endogenous variables that are studied. The final year's results give the total changes in the system after a selected length of time, and include changes in both magnitude and directions. The logic behind the specifications of the behavioral equations will be explained in future sections where the proposed model will be presented in more detail.

IV. ECONOMETRIC CONSIDERATIONS

Recently a number of large-scale simulation models have been constructed. These dynamic econometric models frequently contain structural equations that are nonlinear in the endogenous variables, so that explicit analytical solutions for the reduced-form equations of the models are difficult to obtain. Furthermore, the parameters of the structural equations are often estimated by single-equation methods such as the two-stage least-squares technique. For these reasons, economists have come to rely upon simulation experiments to investigate the dynamic behavior of econometric models. In addition, the system's dynamic coefficients that relate the endogenous variables of the system to the predetermined variables are determined by the simulation experiments (H. H. Kelejian).

Using simulation models raises statistical problems, first with respect to the efficiency of the simulation models based on linear equations as an interrelated system. Second, application of nonstochastic simulation procedures to economic systems containing nonlinearities in the endogenous variables may yield results that are inconsistent with the properties of the model's reduced-form equations. Nevertheless, some dynamic properties of linear models can be inferred from simulation results. This problem is important with respect to model validation and model predictions, especially since the model is recursive. Autocorrelation and heteroskedasticity of the disturbance terms may have serious implications on the model's results, even when the model formulation was correct and properly specified.

There is another practical consideration. Properties of dynamic nonlinear models must be studied from a stochastic framework. Because nonlinear simulation is difficult to accomplish, other methods of approximating the system's equations may need to be used.

Structural and Reduced Forms

Structural equations (forms) express relationships in the economic model. The structural relations and the assumptions about stochastic disturbance terms complete the model's specifications. In other words, these are the equations suggested by the economic theory. A set of unknown parameters and known variables gives a specific structure within the model.

The reduced forms of the model express current values of the system's endogenous variables as an explicit function of all other variables and disturbance terms of the model (exogenous or lagged endogenous variables) so that each equation of reduced form contains only one current endogenous variable.

In general, one must specify as many relations in the model as the number of endogenous variables. The classification into endogenous or exogenous variables is a relative one that depends on the nature and the extent of the system being studied and on the model's purpose.

The reduced form shows the equilibrium impact of change in any exogenous variable on any endogenous variable. From an economic point of view, this is necessary in order to answer policy questions.

Presentation and discussion of the model and submodels structural forms will be made in later chapters.

Identification Problem

The identification problem is that of determining and establishing the number of restrictions necessary to obtain unambiguous estimates of model parameters, or system coefficients. Identification is not a data problem, but a specification problem, and logically precedes estimation.

The relationships between endogenous variables and predetermined variables (exogenous or lagged endogenous variables) are said to be _identified_ if all the parameters in that relationship are identified. Before being concerned with the problem of identification, we must verify that the model is mathematically complete--that there are enough equations to arrive at unique solutions for the endogenous variables.

The identification problem is more than a statistical problem; it is an _economic_ problem as well, and as such requires information on the nature and behavior of the system studied, its exogenous variables, and the system relationships in formulating a model. The requirement for the identity of an equation or system of equations is that the number of predetermined variable excluded from the equation must be at least equal to the number of endogenous variables included in the explanatory variables set of equation.

To summarize, formulating an econometric model or system of equations requires that three questions be answered.

1. Does the system of equations provide a unique solution for the endogenous variables? (Mathematical completeness problem)

2. Do prior restrictions on the model's parameters allow us to identify the first equation? (Identification problem)

3. Assuming exact identification, are problems of multi-collinearity avoided (Wonnacott and Wonnacott, 1970). (Estimation problem)

If the system is not mathematically complete, then the model cannot answer questions of policy, and therefore will not be economically useful. If conditions for answering the second question are not met, then no estimations can be made for any specific equations in our model. Finally, if a multicollinearity statistical problem exists, then the model's parameters cannot be estimated.

Because the proposed model is recursive, the identification problem will disappear if we assume a triangular matrix for the current endogenous variables, and a diagonal variance-covariance matrix for the disturbance terms in difference structural equations. This problem will be discussed in detail in the study.

Estimation Procedures and Remarks on Dynamic Stochastic Model

A number of estimation procedures (Jonston, Christ, Taylor) are available for estimating the parameters values of a system of equations, both single equation methods and system estimation methods. Single equation methods, such as ordinary least-squares (OLS), two-stage least-squares (TSLS), and autoregressive least-squares, may be used in the first part of the submodels construction phase. System estimation methods, such as full information maximum likelihood and three-stage least-squares, may be used in the final stage of the submodel analyses and in the overall regional model. Each method corresponds to a different set of assumptions about the disturbances of the structural equations.

Since the model is at once dynamic and stochastic, it is necessary that the effects of stochastic disturbances on forecasting be considered. Let us briefly consider some of the special features of the model and implications of introducing random disturbances into the dynamic analyses. Note that some analytical tools mentioned above are used in the analysis process of this suggested model.

(a) In dynamic cases, as in static, while the underlying structural equations are correct, predictions based on the reduced form of the model's structural form are imprecise.

(b) This model, like most, assumes the mean of the disturbance term or terms to be zero.

Because of (a) and (b), we can predict only ranges of values that specific variables will take with given uncertainty. Uncertainty of future values of estimated variables, then, increases as the time horizon on which the prediction is based increases. As a result, endogeneous variables will not be exactly predicted, even when exogenous variables, parameters, and initial conditions are known.

(c) To satisfy the requirement of independency, we must redefine exogenous variables in our dynamic stochastic model. It is required that predetermined variables be statistically independent from current and future variables, but not necessarily from past disturbances in the model.

(d) The assumption of independence of disturbance terms of different equations at time t may now be modified as follows: All disturbance terms at one time t are independent from those of other time periods.

(e) To insure that lagged endogenous variables are truly predetermined, it is assumed that, for all time periods, the disturbance terms are independent of not only lagged values (t-1), but of all lagged periods (Christ).

The estimation procedure used in this study will be based generally on typical stochastic hypotheses (Jonston, Christ). Modifications and use of other estimation procedures will be used if necessary.

V DATA

System Variables and Time Factor

The primary data used for the submodels in this study will be time-series aggregate regional data. The study will use information published by the National Statistical Bureau, the Central Bank, and other financial and administrative agencies. To insure that the data is reliable, only firsthand sources will be utilized, that is, central government data. Most of these sources will be government documents that are published annually. These data will be supplemented using statistical publications of international institutions and organizations. Studies that merely cited or used government data will be excluded from our study to avoid possible introduction of personal views rather than strictly measured numerical data.

The data to be collected may be grouped into several areas. These areas include prices and regulations information, capital, labor, land and climate information, services income, marketing information, and supply and demand information. Each group will be divided according to previously defined submodels. The data will be entered either as ordinary values, such as volumes or dollars, or as index numbers. Thirty-one observations, covering the thirty years from 1950 to 1980, are sufficient for the purpose of this study.

The following basic information about the system will be collected:

1. Price information. General price index, price supports during the time studied, oil prices on CIF basis, industrial price index, agricultural price index, domestic food prices, input price index, farm received prices, GNP price deflator.

2. Tax and quota information. Taxation, quotas, rate of exchange information, corporation tax rates, sales tax rates (ICM), import/export quotas, exchange rates with respect to the dollar).

3. Capital information. Capital data, sources/uses, cost of capital, volume of credit by submodels, regional capital stock (machinery and real estate, not including labor), processing, storage and production capacities, energy production capacity, cost of capital according to different credit duration and uses, returns on capital by submodels, corporate profits, rate of capacity utilization.

4. Labor information. Labor and population, population size and growth rates, urban and rural classification, population distribution according to submodels, economically active labor, employment level, education levels of labor force, wage rates (minimum, skilled labor), labor requirement per unit of production by submodels.

5. Climate information. Precipitation, temperature and water supply indices.

6. Income information. Total goods and services produced in the region by private and public sectors, and according to submodels, net transfer from out of the region, income per worker by submodel, income distribution by level and population categories, personal income by submodel, submodels profit level, consumption expenditures, savings per capita and per industry.

7. Marketing information. Inputs and machinery supplies by type, agencies, volume and value, output by volume, value, recipients, import/export by volumes and value. Marketing services by level--retail, wholesale--volume, value, locations. Yearly demand by submodels, yearly supply by submodels. (Supply and demand for each submodel are in terms of value-equivalent unit).

8. Government information. Government income by sources (taxation, production, others), submodel loans to private sector (from in and out of regional sources), subsidies per submodel, cost of social programs, government institutional expenses, government investment by submodels.

9. Finance and banking information. Finance and banking, net private and public debt, use and sources of funds.

10. Business information. Business, business index (consumption, income), corporate business, investment, expenditures, sales, inventories, profit, equity sales.

11. Energy information. Energy production using fuels, electricity, gas, water power, and nuclear power. Trade, uses, consumption, research and development, measured in money value and volume.

12. Transportation information. Transportation (land and maritime), revenues, employment, highway mileage, highway construction, highway funds, motor vehicle operation, carriage (volume and values) by motor, railraod, water, and air.

13. Mining information. Production by volume and value, import/export earnings, labor used.

14. Construction information. Value of new construction, prices, wages and construction index, public housing, mortgage and home loans.

15. Manufacturing information. Production index, manufacturing capacity, establishments and operations, capital expenditures, exports and import out of the region, export-related employment, fuel and energy use, equipment and other capital investment.

16. Agriculture submodel information. Farms by size and numbers, population, acreage, real estate value, irrigation (area and equipments), inputs (volumes and value), marketing services (value), gross product,

income, expenses, debt, credit, input index, productivity index, out-of-submodel trade (classification, volume, value).

17. Trade information. Regional trade (internal and external), regional trade and marketing-financing services (total), retail trade (sales and inventories), public warehousing (volume and values). External trade, out-of-region investment, merchandise trade index, regional export (volume and values) and import.

Data Sources

In the United States, possible sources for the required data are the Organization of American States (OAS), the Food and Agriculture Organization (FAO), and the International Bank of Reconstruction and Development (IBRD) in Washington, D.C.

In Brazil, major possible sources are the Instituto Brasileiro de Geografia e Estatistica (IBGE), Secretaria de Planejamento (SEPLAN), and the Ministries of Mines and Energy, Commerce, and PETROBRAS in Brasilia. In Recife, a source is the Superintendencia de Desenvolvimento do Nordeste (SUDENE); in Fortaleza, the Banco do Nordeste do Brazil (BNB); in Sao Paulo, COPERSUGAR: and perhaps the Empresa Brasileira de Pesquira Agropecuaria in Brasilia, D.F.

Data Analysis

To analyze the data, this study will employ econometric procedures that are used widely in the social sciences. The methods for producing the variables, parameters, and quantitative and qualitative relationships of our system have already been discussed briefly.

Once statistics based on present policy implementation have been produced and rules of system operation have been defined, a simulation model will be constructed. By simulating system behavior and operation, the model will evaluate the long-run effects of the Proalcohol Program on the economic structure of the northeastern region. In our model, policies are defined as a particular fixed values of a given subset of the system's variables. Examples of fixed policy variables are a given level of interest rate for a specific submodel or a minimum guaranteed price. The dynamic nature of the system studied requires adequate methods of analysis that reflect the system's operation and its adjustment mechanism over time intervals.

Treatment of Raw Data

Identification of system submodels, variables, and trend factors

The proposed model contains ten submodels: (1) energy crop sector (sugarcane and mandioca), (2) food and grain crop sector, (3) industrial crop sector (cotton, sisal, tomatoes, cashew, babacu, castor beans), (4) livestock sector (includes milk, beef, and egg production), (5) manufacturing and textile industry sector, (6) processing industry sector, (7) petro-pharmacetic industry sector, (8) other industries such as construction and mining, (9) government sector (services and commerce), and (0) private sector (services and commerce). Services and commerce include transportation, commerce, and banking.

Regression analysis techniques will be used to form the variables for each submodel's set of equations from the raw data. Simultaneously, trends in the data will be determined. For each submodel, pre-input, input, and output equations will be constructed. Finally, an income-generating function will be produced for the submodels.

Pre-input equations. Recursive equations will show what level of resources stock to allocate to any submodel's production. For example, the amount of land used in livestock or in energy crop sectors is determined using pre-input equations.

In pre-input equations, the dependent variable is a function of predetermined variables and of endogenous variables that have been treated as dependent variables earlier in that submodel's pre-input section. Here are some examples of pre-input equations in the energy crop sector:

(1) $Land_{it} = f\ (P_{it-1}, PRAL_{it}, PRAL_{it-1}, LDV_{t-1}, TIME)$ where $Land_{it}$ is land use for energy crop at $Time_t$, P_{it-1} is the price of sugar or mandioca in the previous year, $PRAL_{it-1}$ represents production allotments at current (*t*) and previous years (*t-1*), LDV_{t-1} represents land diverted from other submodels in the previous year, and TIME is a trend variable where 1 represents 1950 and 31 represents 1980.

(2) $Stock_t = f\ (PROD_{t-1}, COMC_{t-1}, GROINC_{t-1}, SGS_{t-1})$, where $Stock_t$ represents inventory at $TIME_t$, $PROD_{t-1}$ represents commercial demand at *t-1*, $GROINC_{t-1}$ represents farm gross income at *t-1*, and SGS_{t-1} represents sugar stock at *t-1*. This equation gives the ending year commodity stock on farms.

(3) $AVESTOK_t = f\ (AVESTK_{t-1}, AVESTOK_t)$ gives the average calendar year stock of commodity for future interest charged on investments.

(4) $MACEU_t = f\ (GROINC_{t-1}, SUBS_{t-1}, EQR_{t-1}, MP_{t-1}, TIME)$, where $SUBS_{t-1}$ represents subsidies to equipment purchases at *t-1*, ERQ represents the equity ratio (real estate value divided by debt), MP represents machinery prices, and TIME represents time trend. The above equation describing machinery and equipment will later enter the production function as flow of services. It assumes that the flow of services is proportional to stock of machinery and other equipment.

Pre-input equations for all submodels will be specified in the final report.

<u>Input equations</u>. Recursive input equations describe (1) monoperiod operating input relationships, and (2) relationships for the flow of services of durable resources, such as real estate, capital, taxation, and interest on loans.

All equations are estimated using original data based on observations for the period 1950-1980. Note that some explanatory variables are treated as dependent in the pre-input sections; therefore adequate estimation techniques must be used for these cases.

An example of type (1) is the following equation:

Variable inputs = f (PVI_t, $PVIX_{t-1}$, $GROINC_{t-1}$, PAS_{t-1}, TIME), where PVI is the price of input variables, PVIX is the price index of variable inputs, GROINC is the gross income, and PAS is the stock of physical assets. An example of type (2) is:

Real estate expenses = f (IDR, REVL, TIME), where IDR represents interest, depreciation and repair expenses for buildings and equipment, and REVL is real estate value.

<u>Output equations</u>. Output equations sets will contain (1) production functions, (2) estimated current input demand (to be fed into production function), (3) supply identities, (4) price equations, (5) commercial demand, (6) inventory estimates (government and commercial), (7) export-import equations, and (8) gross income equations.

These output equations will use the information generated in the pre-input and input sections, either directly or indirectly, or it will use the raw data for estimating prices, for various demand and supply equations, or for the gross income of each submodel. For example, price equations may have the form:

$PRF_t = (SPPR_t, SUPPLY_t, \text{Commercial Demand}_{t-1}, TIME, INCPC_t, INTPR_t)$

where $SPPR_t$ represents price support at the current year, INCPC is income per capita, and INTPR is international price level for one commodity at time t.

Production functions and production elasticity estimations will be explained in detail in the final report.

VI SIMULATION ANALYSIS

To perform simulation analysis, the following four steps will be followed:

1. A computer program will be formulated. This step will involve flow charting, writing or adapting computer programs, error checking, data input, data generating (stochastic variables included), and output report.

2. Results will then be validated by comparing the simulation data generated by the computer with actual historical data. If the model's results and the actual data vary widely, changes will be made in the variables, parameters, and structure of the model.

3. Experiments will next be run. Two possible courses of action can be taken. Either (a) find the factor level combination at which the response variable is optimized, or (b) explain the relationship between the response variables and the controllable variables in the experiment without optimization. In all experiments, special attention will be given to stochastic convergence, to problems of size and motives, and to multiple response problems if they occur.

4. Simulated data can then be analyzed. This analysis will include registering and processing the simulated data, computing test statistics, and interpreting the results.

The above analysis will need to concern itself with the problem of stochastic convergence as it relates to convergence/divergence of the sample means as the number of years (iterations) increased. Also, with respect to the design of the experiment, several factors must be considered: Preliminary test will be made to establish whether the process is reasonable and stable. Possible changes in the external uncontrolled conditions may be considered. Test of the model in its most critical parameters may be performed to establish the system's stability. Finally, the experiment must be conducted under the predetermined hypotheses.

Simulation Procedures

Below is an outline describing simulation procedures in more detail.

A. Model Construction

1. Determine desired level of detail.
2. Select dependent variables, and the exogenous variable to explain the behavior of the selected system's endogenous variables.
3. Sort all subsector equations according to previously laid-out order.
4. Define and construct set of identities to aggregate estimates for submodels into regional estimates.
5. Perform several simulation runs.

B. Model Validation (Test)

1. Check structure of the system's equations.
2. Check consistency of estimation parameters.
3. Check accuracy of estimated variables, and behavior of the system (by estimating the 1980 values based on system performance from 1950-1980).
4. Correct model structure if necessary.

C. Simulation Run--using selected variables and best-fit equations

D. Experiments--answer "if-then" questions by changing selected variables or sets of variables (policies)

1. Eliminate price supports or other subsidies.
2. Eliminate government variables.

3. Increase oil or energy prices, or food prices at various levels.

E. Evaluation of model's results

1. Effect of program on regional economic structure
2. Effect of program on resource use
3. Benefits and costs of the program

Projection Model Analysis

The objective of this stage of the analysis is to answer the questions: Where is the region headed as a result of implementing the Proalcohol Program? What are some effects that can be projected with respect to resources allocation, income generation, and income distribution?

Projections for the year 1990 are based on time paths of the system's endogenous variables generated during the period 1950-1980. A projection period of ten years was selected because it is believed that long-run trends and cycle patterns of the adjustment process can be simulated and quantified in this time horizon.

Procedure. The first simulation year, 1981, will be built on observations of exogenous variables' values for the year 1981, and endogenous variables' values for the year 1980. In this way, projections for the next ten years can then be successively generated. The accuracy of the generated projections depends on how closely they meet certain assumptions: It is assumed that the time parameters are correctly specified and that structural coefficients are accurate. Structural coefficients are assumed to remain the same between the sample and the forecasted period. If structural modifications are made, it is assumed that the modified coefficients are correct. It is assumed that values given for the exogenous variables in our predictive model are the values that will actually be observed. Finally, the values of the disturbance terms are assumed equal to their expected value; that is, zero (standard assumptions of linear regression model).

Before the simulations are run, several starting points must be selected. Domestic and export demand levels will be based upon government consumption and export projections for the year 1990. These projections reflect population growth and consumption per capita for the years 1981 through 1990. Production per unit of resources is assumed to be at the 1980 level. Values of exogenous variables (appearing in the resources demand structural relationships) and values of resources demand for commodities are both assumed to be at the 1980 level. All forecasting of resource needs are based on the assumption that existing policies will continue through 1990. Using the auto-regressive model, projected yield per unit of land will be produced, where exogenous variable values will be estimated using a simple linear trend model.

<u>Limitations</u>. Several statistical problems and limitations of this approach exist and need to be treated and solved in the course of this study.

1. Endogenous variables are projected into the future for several years, based partly on extensions of trends, which require adjusting the equations so that projections stay in reasonable bounds.

2. Problems of consistency of structural coefficients may rise from the projection process.

3. Incomplete published input data may cause problems because then certain data will have to be estimated.

4. Input-output relations must be known; costs and returns must be realistically calculated.

Bibliography

1) Barbosa, T. "The Farm/Nonfarm Interface with Special Reference to Rural Brazil." Plenary and Invited Papers, 17th International Conference of Agricultural Economics. Banff, Canada, 3-12 Sept. 1979. pp. 200.

2) Barzelay, M., and Pearson, S. R. The Efficiency of Producing Alcohol for Energy in Brazil. Food Research Institute, Stanford University, 1980.

3) Carioca, J. A., A. A. Carngiro, and H. L. Arora. "Biomass: Um Programa para Nordeste." Universidade Federal do Ceara, Fortaleza, Brazil, 15 August, 1978.

4) Carioca, J. O., H. L. Arora, and A. S. Khan. "Technological and Socio-Economic Aspects of Cassava Based Autonomous Minidistilleries in Brazil." Universidade Federal do Ceará, Fortaleza, Brazil (1980).

5) Carueiro, D. D. (coordinator). Brasil: Dilemas da Politica Economica. Rio de Janeiro: Editora Campus Ltd., June 1978, capitulus 1, 4, 7, 8.

6) Chambers, R. G., and R. E. Just. "Effects of Exchange Rates Changes on U.S. Agriculture: A Dynamic Analysis." American Journal of Agricultural Economics 63 (1981), pp. 32-46.

7) Christ, C. F. Econometrics Models and Methods. New York: John Wiley, 1966.

8) Cruz, T. A., T. Barbosa, A. B. Oliveria, and J. A. Teiyeira. "Resposta dos Pequenos Agricultores a Estimulos de Preco." Rev. Ceres. 25 (1978):554-572.

9) de Alemida, H. "Politica Nacional do Alcohol." Palesta Realizada em Brasilia. Sept. 1979.

10) de Cruz, E. R. "Rentabilidade Potencial de Microvsinas de Alcohol a Partier de Cana de Acucar." Pesquisa Agropecuaria Brasileira. October, 1980:365-378.

11) de Hean, H. "The Use of Quantitative Sector Analysis in Agricultural Policy." Plenary and Invited Papers, 17th International Conference of Agricultural Economics. Banff, Canada, 3-12 Sept. 1979, pp. 299-312.

12) de Melo, F.B.H. A Agricoltura no Anos 80: Perspectivas e Conflictos entre Objectivos de Politica. Sao Paulo, 1980a, IPE/USP Departmento De Publicacoes, Agencia Pinheiros, Sao Paulo, Marco 1980.

13) de Melo, F. B. H. "Trade Policy, Technology and Food Policies in Brazil." IPE/FEA/USP, Sao Paulo, 1980b.

14) de Melo, F. B. H., and R. P. Eli. "A Crise Energica e o Sector Agricula no Brasil." Trabalo para Discussao. 38 (1980). IPE/USP Department De Publicagoes, Agencia Pinheiros, 05508-San Paulo-SP Julho 1980.

15) de Melo, F. B. H., and Adolpho Walter P. Canton. "Risco na Agricultura Brasileira: Nordeste "Versos Sul," Revista Economica do Nordeste, No. 3, Julho/Setembro 1980, Volum 11, pp. 471-483.

16) Fox, R. "Brazil Minimum Price Policy and the Agricultural Sector of Northeast Brazil." Plenary and Invited Papers, 17th International Conference of Agricultural Economics. Banff, Canada, 3-12 September 1979.

17) Goodman, R. "Managing the Demand for Energy in the Developing Countries." Journal of Finance and Development 17 (1980):9-17.

18) Hammond, A. "Biomass Conversion--A Rediscovered Source of Fuel." Development Digest. Vol. 17, No. 3, July 1979, pp. 4-11.

19) Hertzmark, D., S. Flaim, D. Ray, and G. Parvin. "Economic Feasibility of Agricultural Alcohol Production Within a Biomass System." American Journal of Agricultural Economics 62 (1980), Proceeding Issue, pp. 965-971.

20) Holanda, A. A. "O Credito e o Desenvolimento de Fontes Renovavies de Energia." Revista Economica do Nordeste. 2 (1980):355-379.

21) Jonston, J. Econometric Methods. New York: McGraw-Hill, 1972.

22) Koopmans, T. C., and W. C. Hood. "The Estimation of Simultaneous Linear Economic Relationship." Journal of the American Statistical Association (1953), pp. 448-466.

23) Koopmans, T. C., and H. Rubin, and R. B. Leipnik. "Measuring the Equation System of Dynamic Economics." In Koopmans (1980), 53-237.

24) Leite, P. S. "Contribuicao da Agroinstria para o Desenvolvimento do Nordeste." Revista Economica do Nordeste 2 (1980), pp. 427-452.

25) Mattuella, J. L. Economic Impact of Alcohol Production on Agriculture in Southern Brazil, Ph.D. thesis, Ohio State University, 1980.

26) Naylor, T. H. The Design of Computer Simulation Experiments. Durham, N. C. Duke University Press, 1969.

27) Nicholis, W. N. "An Agricultural Supplies as a Factor in Economic Development." Journal of Political Economy 71 (1963), 1-29.

28) Paiva, R. M., S. Schattam, C. F. T. de Freitas. "Brazil's Agricultural Sector Economic Behavior, Problems and Possibilities." Rio de Janeiro, 1977.

29) Scandizzo, Pasqual L. and T. Barbosa. "Substitu Acao e Proctividade de Fatores na Agricultura Nordestina." Pequisa e Planejamento 7 (1977):367-432.

30) Scandizzo, Pasqual S. and T. Barbosa. "Elestisidade de Escala e Tava de Incentivos a Exportacao." Pesquisa e Planjamento Economico, Vol. 7, August 1977, pp. 367-432.

31) Rask, N. Farm Growth in Brazil. Report of Department of Agricultural Economics and Rural Sociology, Ohio State University, October 1980.

32) Rask, N. and R. I. Adams. Regional Competitiveness of Alcohol Production in Brazil. Report of Department of Agricultural Economics and Rural Sociology, Ohio State University, 1980.

33) Ray, D. E. An Econometric Simulation Model of U.S. Agriculture with Commodity Submodels. Ph.D. thesis, Iowa State University, Ames, Iowa, 1981.

34) Rossmiller, G.E. Agricultural Sector Planning, A General System Simulation Approach. Michigan State University, 1978. Department of Agricultural Economics, Library of Congress Catalog Card Number 77-092693.

35) Schuh, G. E. "Floating Exchange Rates, International Interdependence, and Agricultural Policy." Plenary and Invited Papers, 17th International Conference of Agricultural Economics. Banff, Canada, 3-12 September 1979, pp. 416-423.

36) Singer, F. S. "The Coming Revolution in World Oil Market." Wall Street Journal. Editorial, 4 February, 1981

37) Truran, J. A., and R. W. Fox. "Resources Productivity of Landowners and Sharecroppers in the Cariri Region of Ceará, Brazil." Land Economics (1979): February, pp. 1-55.

38) Tyner, F. H. and L. G. Tweeten. "A Methodology for Estimating Production Function Parameters." American Journal of Agricultural Economics 47 (1965): 1462-1466.

39) Wonnacott J. R., and T. H. Wonnacott. Econometrics. New York: John Wiley, 1970.

40) World Bank Report. Alcohol Production from Biomass in Developing Countries, Washington, D.C. September 1980.

41) Hall, Anthony L., Drought and Irrigation, Northeast Brazil. Cambridge University Press, 1978.