# TECHNOLOGY CHOICE AND DEVELOPMENT IN BRAZIL:
# AN ASSESSSMENT OF BRAZIL'S ALTERNATIVE FUEL PROGRAM AND THE AGRICULTURE, MANUFACTURING, ENERGY, AND SERVICE SECTORS

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Technology choice profoundly affects a country's development process because capital-intensive and labor-intensive technologies have different socioeconomic linkages within the economy. This research examines the impacts of technology choice through the use of a social accounting matrix (SAM) framework. SAM-based modeling determines the direct and indirect effects of technology choice on development, particularly poverty alleviation in Brazil. Brazil's alternative fuel program was analyzed as a special example of technology choice. Two ethanol production technologies and the gasoline sector were compared; to make the study more robust, labor and capital intensive technologies were evaluated in the production of agriculture, manufacturing, energy, and services. Growth in these economic sectors was examined to assess the effects on employment, factor and household income, energy intensity, and carbon dioxide costs. Poverty alleviation was a focus, so income to unskilled agriculture labor, unskilled non-agriculture labor, and income to rural and urban households in poverty was also analyzed.

The major research finding is that overall, labor-intensive technologies generate more employment, factor and household income, environmental and energy benefits to Brazil's economy than capital-intensive technologies. In addition, labor-intensive technologies make a particular contribution to poverty alleviation. The results suggest that policies to encourage the adoption of these technologies, especially in the agriculture and renewable energy sectors, are important because of their intersectoral linkages within the economy.

Many studies have shown that Brazil's fuel ethanol program has helped to realize multiple macroeconomic objectives. However, this is the first empirical study to quantify its household income effects. The ethanol industry generated the most household income of the energy sectors. The research confirms a key finding of the appropriate technology literature, namely that government policies are important to the implementation of labor-intensive technologies.

Finally, this research makes two important contributions to the SAM methodology. It is one of the first SAM modeling exercises to quantify the costs of carbon dioxide emissions and the impact of alternative fuels on regional and human development. The addition of an environmental sector enables the planner to determine carbon dioxide effects resulting from growth in different socioeconomic sectors. This will have implications for greenhouse gas mitigation strategies.

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# CHAPTER ONE

# INTRODUCTION

Technology choice is an important socioeconomic development issue because different techniques often imply different strategies of economic development with very different effects on the performance of the economy.[1] Others state more explicitly:

> The choice of technologies is one of the most important collective decisions facing a developing country. It is a choice which affects the whole fabric of the economic and social structure. It determines who works and who does not; the whole pattern of income distribution, where work is done and therefore the urban/rural balance; what is produced and for whose benefit resources are used.[2]

This research examines the social, economic, energy, and environmental effects of several production technologies. Brazil's alternative fuel program is analyzed as a special example of a technology choice. In addition, the employment, labor and household income, energy as well as environment effects of different

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[1]Amartya Sen, *Choice of Techniques: An Aspect of the Theory of Planned Economic Development* (New York: Augustus M. Kelley, 1968), 2.

[2]Intermediate Technology Development Group, *Journal of Appropriate Technology* (London: Intermediate Technology Development Group, n.d.), 2.

economic sectors are evaluated. Labor and capital intensive technologies are compared in the production of agriculture, manufacturing, energy, and services. The findings of this analysis have implications for development planning.

Brazil can provide many insights into the use of alternative transportation fuels because of its extensive experience with ethanol. Brazil's development of a domestic gasoline substitute, based on ethanol produced from sugarcane, is today the largest alternative transportation fuel program worldwide. Public policy makers promoted the biomass fuel program as a means to help meet its energy needs, and at the same time, contribute to its overall development.

## SECTION ONE: BRAZIL'S ALTERNATIVE FUEL PROGRAM

Brazil's alternative transportation fuel program, called *Proalcool*, was explicitly justified as part of a development strategy. In 1974, Brazil's oil import bill was 39.5% of total exports.[3] Policy makers adopted an alternative transportation fuel policy in 1975, primarily to save foreign exchange and to be energy self-sufficient. Other objectives included: to stimulate rural employment, to reduce regional income inequality, to utilize surplus agricultural feedstock, and to foster a domestic research and development capability in distillation technology and machinery.[4] Brazil's

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[3]Mark Levison, "Alcohol Fuels Revisited: The Costs and Benefits of Energy Independence in Brazil," *The Journal of Developing Areas* 21 (April 1987): 243.

[4]Plinio Nastari, "The role of sugarcane in Brazil's history and economy" (Ph.D.

program has been successfully implemented because of government policies affecting both production and consumption. These policies include subsidies, tax incentives, and differential fuel pricing.

*Proalcool* is the most extensive domestic gasoline substitute program in the world. About 685 distilleries with an installed capacity of over 16 billion liters, produce some 12 billion liters of ethanol annually. Currently, ethanol is the primary automotive fuel in Brazil with 75% of the passenger cars operating on either pure ethanol (which is 77% to 83% as efficient as gasoline) or an ethanol-gasoline blend (which is as efficient as gasoline).[5] An estimated 30% -- or 4.5 million—of Brazil's current passenger vehicles operate only on pure ethanol (also known as neat or hydrous ethanol), and 5 million cars run on gasoline that is blended with 22% ethanol (also known as anhydrous ethanol).[6] Between 1976 and 1990, total investment in Brazil's *Proalcool* program amounted to $10.5 billion (in September 1990 dollars), and saved the country $18.3 billion in foregone oil imports as of 1990.[7] Projections

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diss., Iowa State University, 1983), 112.

[5]Kevin Rask, "The Social Costs of Ethanol Production," *Economic Development and Cultural Change* 43, no. 3 (1995): 630-631.

[6]Jose Goldemberg, L. Monaco, and I. Macedo, "The Brazilian Fuel Alcohol Program," in *Renewable Energy: Sources for Fuels and Electricity*, ed. T.B. Johansson, K. Kelly, A. Reddy, and R. Williams (Washington, D.C.: Island Press, 1993), 843.

[7]Plinio Nastari, "Turbulence Marks Brazil's Alcohol Program," *Fuel*

for *Proalcool's* direct employment is estimated to be about 700,000.[8] The substitution of gasoline has avoided the release into the atmosphere of an average of 5.86 million tons of carbon per year (MtC/year) from 1980 to 1990, which is almost 25% of Brazil's total carbon dioxide emissions contribution caused by the transport sector (24 MtC) in 1990.[9] In addition, the World Bank reports that ethanol-powered cars reduce emissions of lead by 100%, carbon monoxide by 57%, hydrocarbons by 64%, and nitrogen oxides by 13%.[10]

While the socioeconomic and environmental benefits of *Proalcool* are documented, controversy has always surrounded Brazil's national ethanol program. The assessments of the socioeconomic impacts of the ethanol industry are contentiously debated. There is consensus that Brazil has been extremely successful in developing a substitute for gasoline in the transportation sector. However, the major criticism is the opportunity cost of government support for the alternative fuel program. Critics of the program claim the ethanol program is too costly and the

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*Reformulation* (January/February 1992): 51.

[8]Ibid.

[9]E. Lebre La Rovere and P. Audinet, "Environmental Benefits of the Brazilian Ethanol Programme," Proceedings From the First Biomass Conference of the Americas: Energy, Environment, Agriculture, and Industry (Golden, CO: National Renewable Energy Laboratory, 1993), 1540.

[10]World Bank, *Project Completion Report, Brazil - Alcohol and Biomass Energy Development Project* (Washington, D.C.: The World Bank, 1990), 61.

primary beneficiaries of the program are special interest groups involved in the production, distribution, and consumption of ethanol, i.e., land owners who produce sugarcane, the distillation industry, and the privileged class who own cars. This study intends to evaluate the direct and indirect effects of the alternative fuel industry.

## SECTION TWO: RESEARCH OBJECTIVES

The overall objective of this research is to assess the extent to which different economic sectors contribute to Brazil's development objectives. This study examines the effects of several comparative technologies on poverty alleviation. The ethanol industry is evaluated as a special example of technology choice. Two ethanol production techniques are analyzed for their employment, income generation and distribution, energy consumption, and environmental effects. Brazil's response to the energy crises of the 1970s has important implications for energy, environmental, and agroindustrial policies. It is also instructive for countries that have the potential to produce a renewable biomass alternative to petroleum.

In addition, the employment, income, energy, and environmental effects are compared between a relatively labor-intensive technology and a capital-intensive technology in the production of agriculture, manufacturing, energy, and service sectors. Analysis of the economic sectors shows the production activities that most benefit the poorer households; it also highlights differences due to technology choice.

This study permits an examination of the impact of growth in specific economic sectors on poverty. Growth rather than poverty alleviation has been the priority of the Brazilian government. Brazil has high income inequality with marked regional income differences. Income inequality appears to have increased significantly in the 1960s; however, during the 1970s the trend was much milder and the level of absolute poverty declined in the 1970s.[11] The proportion of families in poverty hardly budged from 1960 to 1970, but fell appreciably from 1970 to 1980 - from 38% to 22% of the population.[12]

Table 1 shows the number of families below the poverty line in 1960, 1970, and 1980. In 1940, about 30% of the Brazilian population lived in urban areas, while 70% lived in rural areas. The census of 1980 showed the proportions reversed, with about 70% of the population living in urban areas.[13] Agriculture is still responsible for about a third of all existing jobs, compared to about 55% in 1940. About 30% of GDP was generated by the agriculture sector in 1940, and about 12% in the early 1980s.[14]

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[11]Angus Maddison and Associates, *The Political Economy of Poverty, Equity, and Growth: Brazil and Mexico* (Washington, D.C.: The World Bank, 1992), 79.

[12]Ibid., 95.

[13]Antonio Brandao and J.L. Carvalho, *Trade, Exchange Rate, and Agricultural Pricing Policies in Brazil* (Washington, D.C.: The World Bank, 1991), 11.

[14]Ibid.

Table 1. Number of families below the poverty line, 1960, 1970, 1980.

| Measure | 1960 | 1970 | 1980 |
|---|---|---|---|
| | | | |
| Poverty line (current new Cr$) | 3.30 | 150.00 | 4153.50 |
| Deflator | 1.00 | 45.46 | 1258.64 |
| Poverty line in 1960 prices (new Cr$) | 3.30 | 3.30 | 3.30 |
| | | | |
| Number of families in poverty ($10^6$) | 5.27 | 7.04 | 5.83 |
| Total number of families ($10^6$) | 13.55 | 18.58 | 26.87 |
| Percentage of families below poverty line | 38.90 | 37.90 | 21.70 |
| Urban population %[a] | 47 | 58 | 70 |

Source: Unpublished estimates by A.V. Villela and Associates in Maddison and Associates. *The Political Economy of Poverty, Equity, and Growth: Brazil and Mexico* (New York: Oxford University Press, 1992), 95. © by Oxford University Press. [a] "Reprinted from *Energy Policy*, Gilberto De Martino Jannuzzi, Residential energy demand in Brazil by income classes, 254-263. © (June 1989), with permission from Elsevier Science."

A. Need for Study

In recent years, research has been done to assess the socioeconomic impacts of the ethanol industry in Brazil.[15] Almost all conclude that the technical

[15]Goldemberg et al., The Brazilian Fuel Alcohol Program; F. Joseph Demetrius, Brazil's National Alcohol Program: Technology and Development in an Authoritarian Regime (New York: Praeger, 1990); Armand Pereira, Ethanol, Employment and Development: Lessons from Brazil (Geneva, Switzerland: International Labour Organization, 1986); R. Bhatia and A. Pereira, ed., Socioeconomic Aspects of Renewable Energy Technologies (New York: Praeger

implementation of the biomass energy program has been a success, and that there have been significant foreign exchange savings and employment generation. Against these gains are cited a worsening of regional and individual income distribution for which there are only descriptive assessments. The current research will provide an empirical analysis of the distributional effects within a methodological framework capable of measuring both the direct and indirect employment, income distribution, and environmental consequences of the alternative fuel program.

Additionally, this research will contribute to the literature on science, technology, and development, especially technology choice and its social and economic consequences. Specifically, this study will show the employment, income, energy, and environmental effects of two different production techniques across several economic sectors. The research findings will have policy implications for poverty alleviation and overall development objectives.

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Publishers, 1988); World Bank, *Project Performance Audit Report, Brazil: Alcohol and Biomass Energy Development Project* (Washington, D.C.: The World Bank, 1990); World Bank, *Alcohol Production from Biomass in Developing Countries.* (Washington, D.C.: The World Bank, 1980); U.S. Department of Energy, Office of Policy, Planning and Analysis, *Assessment of Costs and Benefits of Flexible and Alternative Fuel Use on the U.S. Transportation Sector. Progress Report Two: The International Experience* (Springfield, VA: National Technical Information Services, August 1988); Daniel Sperling, New Transportation Fuels: A Strategic Approach to Technical Change (Berkeley, CA: University of California Press, 1988); Fred Moavenzadeh and David Geltner, *Transportation, Energy and Economic Development: A Dilemma in the Developing World* (New York: Elsevier, 1984).

B. Specific Approach of Study

This research provides an assessment of a technology choice within the macroeconomic framework of a social accounting matrix (SAM). It empirically illustrates the relevancy of a SAM in capturing the policy implications of choosing between alternative technologies. A novel contribution of this research is the incorporation of a pollution sector to the SAM methodology. Given the carbon emissions from the energy sector and conservative carbon emission costs from the Intergovernmental Panel on Climate Change, the carbon dioxide ($CO_2$) costs are estimated. Therefore, the $CO_2$ costs of different policies can also be captured. This study is the second analysis,[16] which uses data between 1975 and 1985 to assess the extent to which the government's explicit objectives were being met through the end of the second five-year period. The findings will contribute to the alternative energy discussion and assist in future energy policy formulation.

A second novelty of this research is that it includes an empirical analysis of the employment effects of industrialization between 1960 and 1990. Using data from the 1993 United Nations Macroeconomic Data System, it compares rates of labor absorption with industry growth rates. Policymakers, particularly of those countries experiencing chronic unemployment, may find the SAM methodology a useful short-term planning tool.

[16]Demetrius, *Brazil's National Alcohol Program*.

## C. Research Hypotheses

1. The adoption of labor-intensive technologies provides greater employment than relatively more capital-intensive technologies. Brazil's ethanol sector provides greater employment than the gasoline sector. In addition, Brazil's traditional agriculture, non-durable consumer goods, and private service sectors generate more employment than the export agriculture, durable consumer goods, and public and financial/commercial service sectors.

2. The adoption of labor-intensive technologies provides greater total labor and capital income than relatively more capital-intensive technologies. Brazil's ethanol sector provides more factor income than the gasoline sector. In addition, Brazil's traditional agriculture, non-durable consumer goods, and private service sectors generate more factor income than the export agriculture, durable consumer goods, and public and financial/commercial service sectors.

3. The implementation of labor-intensive technologies increases the income received by the lower income rural and urban households. Brazil's ethanol sector generates greater income than the gasoline sector to the following households: rural workers, rural managers, organized urban labor, and non-organized urban labor. In addition, Brazil's traditional agriculture, non-durable consumer goods, and private service sectors provide more income to rural and urban households in

poverty than the export agriculture, durable consumer goods, and public and financial/commercial service sectors.

4. Certain kinds of government policies are needed to support labor-intensive technologies. A decrease in government expenditures for the ethanol sector will negatively affect employment within the energy sector and income distribution to lower income rural and urban households: rural workers, rural managers, organized urban labor, and non-organized urban labor. In addition, a decrease in government expenditures in Brazil's traditional agriculture, non-durable consumer goods, and private service sectors will negatively affect employment within the energy sector and income distribution to the rural and urban households in poverty than the export agriculture, durable consumer goods, and public and financial/commercial service sectors.

5. Labor-intensive technologies have lower environmental and energy costs than comparative capital-intensive technologies. The use of ethanol has lower $CO_2$ and conventional energy costs than gasoline. In addition, Brazil's traditional agriculture, non-durable consumer goods, and private service sectors have lower $CO_2$ and non-renewable energy costs than the export agriculture, durable consumer goods, and public and financial/commercial service sectors.

## D. Research Methodology

The SAM is an analytical framework which summarizes the interrelationships among the structure of production (including output by economic sector); the distribution of value added going to factors of production (including employment); and the income distribution by socioeconomic groups (households) as well as the corresponding consumption and savings behavior of these socioeconomic groups. It reveals how changes in production affect household income distribution and how household income affects final demand. This relatively new framework is meaningful because one can more fully comprehend how technology and government policies affect production sectors, and in turn how production sectors affect the entire economy, especially the employment and household income.

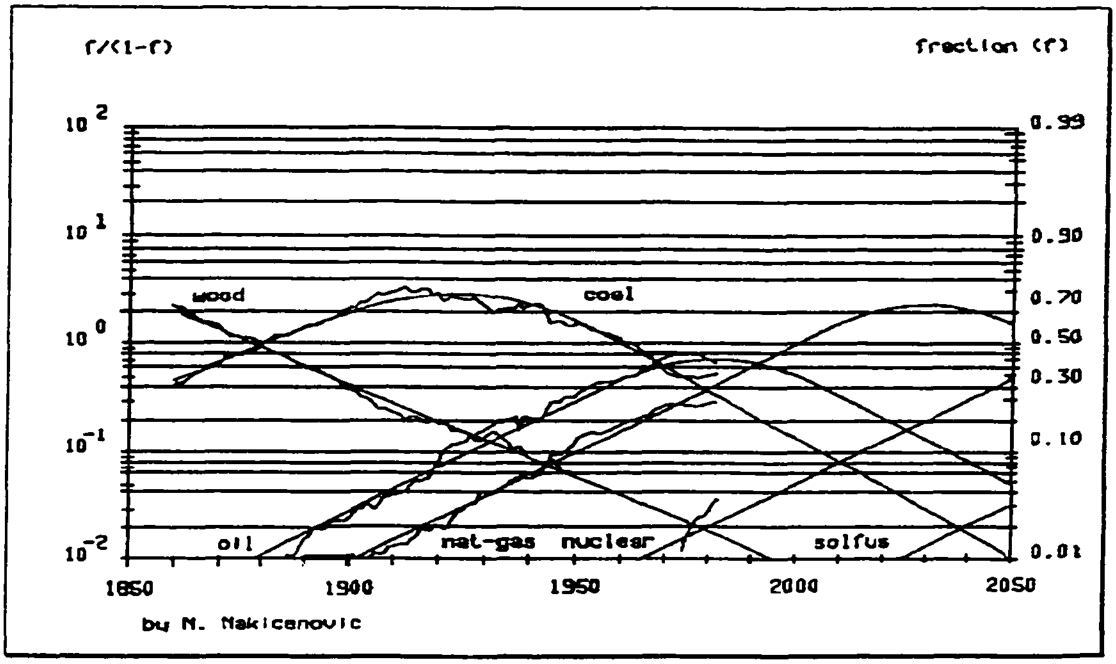
The hypotheses are tested within the open Keynesian multisectoral approach of a SAM framework. The testing incorporates comparative static exercises relying on fixed price multipliers and structural path analysis. This methodology shows the employment and income distribution effects resulting from changes in expenditure patterns due to changes in technology or government policies. Fixed price multipliers, derived from a SAM model, are used to assess how changes in technology or government policy affect the employment and household income of different economic sectors. Structural path analysis decomposes the fixed price multiplier to capture the direct and indirect results of such changes upon the entire socioeconomic system.

This research is interesting because the methodology can capture the socioeconomic differences due to technology choice. It also contributes to the literature on alternative fuels which are becoming more important for environmental public health reasons.

## SECTION THREE: ALTERNATIVE FUEL DEVELOPMENT

Alternative fuels have been integral to the evolution of transportation energy systems. Figure 1 shows the outcome of underlying developments in the transportation sector which has resulted in the substitution of traditional fossil fuel energy sources, based first on coal and steam, then on oil and natural gas, and more recently, but to a lesser extent, on nuclear and hydro energy. Fuelwood and traditional energy sources dominated primary energy until 1880, as canal transport peaked in 1836 and feed for horses and working animals reached a maximum in the 1870s. Coal became the major fuel source between 1880 and 1960 and was the basis for the massive expansion of railroads and steamships. Steam systems peaked in the 1920s and declined thereafter due to the development of internal combustion engine systems of automobiles. Since 1960, oil has become the primary transportation energy source. Historically, the development of transportation technologies and their fuels has occurred cyclically as technologies have provided the means to increase distances involved in the transport of people, goods, and services in shorter periods of time. The steam ship replaced the sail boat, the electric motor replaced the stationary coal-fired steam engine, and the internal combustion engine powered car replaced the horse.[17]

FIGURE 1. GLOBAL PRIMARY ENERGY SUBSTITUTION.




"Reprinted from *Energy* 18, no. 5, N. Nakicenovic, *et. al.*, Long-Term Strategies for Mitigating Global Warming, 401-609, © (1993), with permission from Elsevier Science."

Alternative fuels have minimally affected modern motor vehicle transportation systems. One percent of the world's motor vehicles use fuels other than gasoline or

[17]Arnulf Grubler *et al.*, *Dynamics of Transport and Energy Systems* (Laxenburg, Austria: IIASA, RR93-19, 1993), 11-14. See also A. Grubler and N. Nakicenovic, *Evolution of Transport Systems: Past and Future* (Laxenburg, Austria: IIASA, 1991).

diesel fuel.[18] Three major alternative transportation fuels are used today: ethanol, compressed natural gas (CNG), and liquefied petroleum gas (LPG). Only Brazil, the Netherlands, and New Zealand have alternative fuel programs affecting significant portions of their motor vehicles. The United States Energy Policy Act (EPACT) of 1990 is expected to increase the number of alternative fuel vehicles from less than 5% of the total vehicle fleet in 1990 to over 30% in 2010. Figure 2 shows the percentage of alternative fuel vehicles in selected countries.

The recent development of alternative transportation fuels initially occurred as a result of the energy crises of the 1970s and early 1980s. The 1973-74 quadrupling of oil prices successfully led the commercial, residential, agricultural, and industrial sectors to greater efficiency, conservation, and alternative fuel use. However, transportation systems have been largely unable to achieve large-scale fuel diversification or fuel flexibility and remain dependent upon petroleum.

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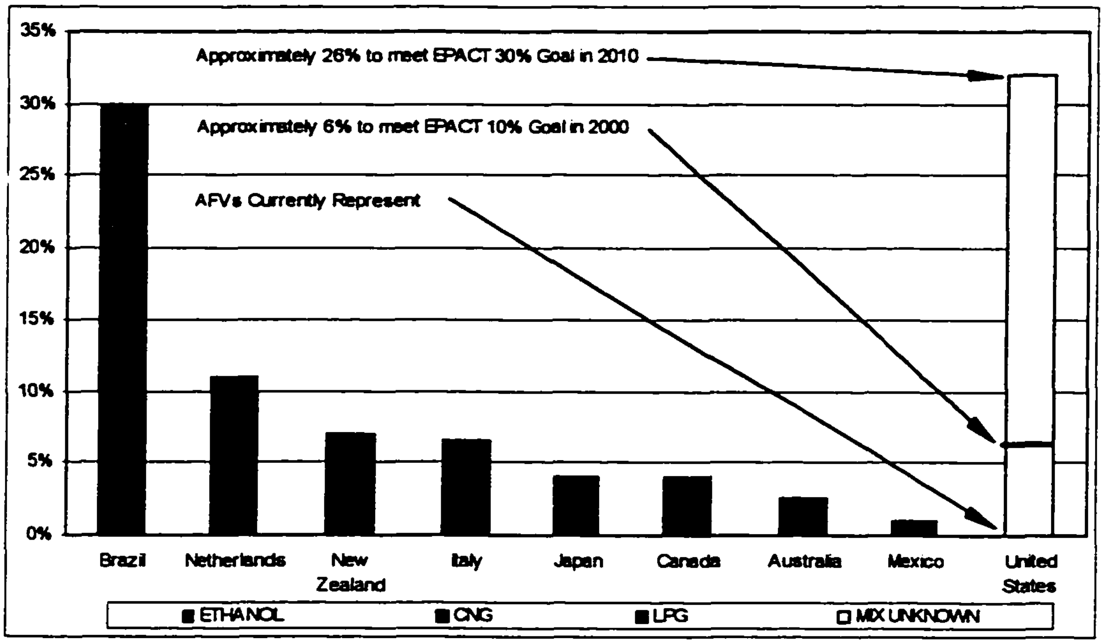
[18]U.S. Dept. of Energy, *EPACT Section 506: Technical and Policy Analysis*, (Washington, D.C.: Office of Transportation Technologies, in press), E-1.

FIGURE 2. ALTERNATIVE FUEL VEHICLES AS A PERCENTAGE OF TOTAL VEHICLE FLEET.




Source: U.S. Dept. of Energy, *EPACT Section 506: Technical and Policy Analysis*, (Washington, D.C.: Office of Transportation Technologies, in press), E-13.

Today, it is the environmental and socioeconomic costs associated with fossil fuel use, i.e., greenhouse gas emissions, ground level ozone, acid rain, and air toxics that are driving the development of alternative transportation fuels. The U.S. Environmental Protection Agency (EPA) estimates that gasoline vapors and motor vehicle emissions account for roughly 50% of the ozone, 75% to 90% of the carbon monoxide, and about 50% of the airborne toxics that put people at risk of cancer.[19]

[19]U.S. Environmental Protection Agency (EPA), "Health Risk Perspectives on Fuel Oxygenates," 600/R-94/217 (Washington, D.C.: Office of Research and Development, December 1994), 2.

Fossil energy consumption associated with human activities is responsible for 70% to 90% of carbon dioxide emissions, the major greenhouse gas.[20] In 1990, fossil energy consumption emitted about 5.5 billion tonnes of carbon (GtC) into the atmosphere; the transportation sector was responsible for more than 1 GtC and for approximately 22% of global final energy consumption.[21] The World Bank states, "motor vehicles cause more air pollution than any other single human activity."[22] The worldwide fleet is estimated at over 580 million motor vehicles with over 400 million passenger cars.[23]

The transport sector is of particular interest because it is the fastest growing energy end-use category. It is this sector where the impact of population growth on natural resource consumption, and resulting environmental pollution, is perhaps the

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[20]Intergovernmental Panel on Climate Change (IPCC), *Energy Supply Mitigation Options: Review Draft (*Geneva: IPCC,1994), 4.

[21]N. Nakicenovic *et al.*, "Long-Term Strategies for Mitigating Global Warming," *Energy* 18, no. 5 (1993): 404 and 556.

[22]A. Faiz *et al.*, Automobile Air Pollution: Issues and Options for Developing Countries, working paper no. 492 (Washington, D.C.: The World Bank, August 1990), 14.

[23]National Alternative Fuels Hotline for Transportation Technologies, "International Alternative Fuel Vehicle Count Estimates," mimeo, (Washington, D.C.: National Alternative Fuels Hotline,1994); and Nakicenovic *et al.*, "Long-Term Strategies for Mitigating Global Warming,", 556.

most indirect of all energy demand categories.[24] The transportation sector accounts for over 50% of total oil consumption in developing and developed countries.[25] Energy use for transportation in the developing world is expected to grow rapidly in the future, as increasing urbanization and growing incomes lead to greater demand for transportation services.[26]

Andreas Schafer's study on global motorized mobility trends confirms the direct relationship between economic development and motorized transportation services.[27] His research finds that as per capita gross domestic product (GDP) increases so does motorized mobility. If global per capita GDP continues to increase annually by 2%, as it has between 1960 and 1990, then global motorized mobility per capita will double by 2020. Schaefer concludes that if the world population increases

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[24]Arnulf Grubler, "The transportation sector: growing demand and emissions," *Pacific and Asian Journal of Energy* 3 (1993): 179-199.

[25]U.S. Congress, Office of Technology Assessment, *Fueling Development: Energy Technologies for Developing Countries*, OTA-E-516 (Washington, D.C.: U.S. Government Printing Office, April 1992), 145.

[26]U.S. Congress, Office of Technology Assessment, *Energy in Developing Countries*, OTA-E-486 (Washington, D.C.: U.S. Government Printing Office, January 1991), 76.

[27]Andreas Schaefer, "Trends in Global Motorized Mobility: The Past 30 Years and Implications for the Next Century," forthcoming, 1-23.

by 50% between 1990 and 2020, [28] then absolute motorized mobility will increase by a factor of three.

Schaefer's study highlights the importance of motor vehicles. He calculates that worldwide passenger car traffic volume increased from 3 trillion passenger kilometers (passenger-km) in 1960 to some 10 trillion passenger-km in 1990. Between 1960 and 1990, bus passenger-km increased from 1 trillion to almost 7 trillion; railway passenger-km increased from 1 trillion to 2 trillion, and aircraft passenger-km increased from 150 billion to 2 trillion. He found that in 1990, 75% of total car traffic volume occurred in the most industrialized countries, while developing countries account for almost 80% of global bus passenger-km.[29] It is expected that as per capita income increases in the developing world, there will be a significant increase in motor vehicle transportation.

Automobiles are integral to current transportation systems. In 1986, the number of automobiles per 1000 people in China was less than 2; in Brazil, 87; and in the U.S., 673 -- whereas, the average annual growth in automobile size between 1982 and 1986 was 41.6% in China, almost 9% in Brazil, and 2.4% in the U.S.[30]

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[28]United Nations, *World Population Prospects: The 1992 Revision* (New York: United Nations, 1993), 6.

[29]Schaefer, "Global Motorized Mobility Trends," 3.

[30]U.S. Congress, Office of Technology Assessment, *Energy in Developing Countries*, 12.

Table 2. Percentage annual growth rate of passenger fleet in select countries.

| Country Group | Passenger Cars | Commercial Vehicles | Two & Three Wheelers | Total |
|---|---|---|---|---|
| DEVELOPING COUNTRIES | | | | |
| Cameroon | 11.8 | 29.5 | 9.1 | 13.1 |
| Kenya | 3.2 | 3.7 | 4.0 | 3.3 |
| Bolivia | 8.6 | 24.5 | 6.9 | 11.6 |
| Brazil | 8.9 | 7.3 | 25.6 | 9.8 |
| Thailand | 8.8 | 4.4 | 9.5 | 8.8 |
| India | 8.2 | 11.2 | 25.4 | 18.4 |
| China | 41.6 | 14.8 | 44.9 | 29.8 |
| Taiwan | 16.2 | 5.4 | 10.3 | 13.9 |
| Weighted Average | 10.0 | 11.4 | 19.1 | 13.9 |
| INDUSTRIAL COUNTRIES | | | | |
| Japan | 3.0 | 4.1 | 7.0 | 4.4 |
| US | 2.4 | 3.5 | -5.6 | 2.3 |
| West Germany | 3.3 | 0.4 | -2.2 | 2.6 |
| Weighted Average | 2.6 | 3.6 | 2.4 | 2.8 |

Source: U.S. Congress, Office of Technology Assessment, *Energy in Developing Countries*, OTA-E-486 (Washington, D.C.: U.S. Government Printing Office, January 1991), 12.

Table 2, incorporating commercial vehicles as well as two and three wheelers, shows that the weighted average of total annual vehicle fleet growth in developing countries is five times greater than in industrial countries. Further evidence which supports the trend toward independent travel is the World Bank's worldwide funding of highways which increased from $2.5 billion in 1970 to $14.3 billion in 1986. Total investment in transportation systems went from $5.3 billion to $26.9 billion during the same period

The U.S. Office of Technology Assessment identifies increases in worldwide population growth rates and industrialization as the two major forces driving global energy consumption levels higher. Today, developing countries have 4 billion people or 77% of the world's population; they are projected to account for 88% of the global population by 2100, virtually all of the projected increase in global population.[31] This population growth will need services which require commercial energy to provide employment, housing, and food. Management of energy development to improve the living standards of growing populations has far reaching environmental and socioeconomic impacts for both developing and industrialized countries.

Development was central to the 1992 United Nations Conference on the Environment and Development (UNCED) in Rio de Janeiro, Brazil. The conference underscored the importance of alternative energy for sustainable development:

> The goal of sustainable development cannot be realized without major changes in the world's energy system. Accordingly, Agenda 21, which was adopted by UNCED, called for "new policies or programs, as appropriate, to increase the contribution of environmentally safe and sound and cost-effective energy systems,

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[31]Ibid., 11.

particularly new and renewable ones, through less polluting and more efficient energy production, transmission, distribution, and use.[32]

The United Nations Framework Convention on Climate Change, ratified in March 1994, requires signatory countries to submit national plans for implementing the Convention. These national plans will affect transport energy supply and demand. For these reasons, alternative transportation fuels are becoming increasingly important to countries' energy management and development planning. Brazil's alternative fuel program is an interesting case study because it was a unique response to the energy crises of the 1970s. Policy makers incorporated energy management and development planning to enact an alternative transportation fuel program that provides substantial environmental and socioeconomic development benefits.

SECTION FOUR: CONCLUSION

This research examines the pioneering effort of Brazil to utilize sugarcane as an alternative transportation fuel in response to the energy crisis of the 1970s. Brazil formulated and developed a national energy policy based on a certain set of factors which existed in 1974; these factors have since changed. Policymakers are now forced to reconsider the extent to which they can continue to support the program in light of low oil prices.

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[32]T. Johansson, H. Kelly, A. Reddy, R. Williams, *Renewable Energy: Sources for Fuels and Electricity* (Washington, D.C.: Island Press, 1993), preface.

It also assesses the direct and indirect social, economic, energy, and environmental impacts of several production technologies. A labor-intensive technology and a capital-intensive technology are compared in the agriculture, manufacturing, energy, and service sectors. The research hypotheses posit that the labor-intensive technologies generate more employment, provide greater labor and household income, utilize less energy, and have lower environmental costs than the capital-intensive technologies. Furthermore, government support of the labor-intensive technologies is warranted because labor-intensive technologies make a greater socioeconomic contribution to the Brazilian economy than capital-intensive technologies.

The direct and indirect linkages of the different technologies can be seen in a SAM-based model. The fixed price multiplier and structural path analysis, based on the SAM model, capture the employment, income distribution, and output impacts of technology choice and government policies upon the energy, agriculture, manufacturing, and service sectors as well as on the entire economic system. This research has implications for energy, agriculture, and industrial policy.

This study is particularly relevant to countries which have the potential to produce an alternative to petroleum given the increasing demand for oil in developing countries, increasing independent automotive travel, and increasing environmental pressure to develop cleaner transportation fuels. It also shows the impact of growth in specific sectors of the economy on poverty alleviation as well as the socioeconomic and environmental consequences of technology choice in the agriculture, manufacturing, energy, and service sectors. These results will provide policymakers with data on how certain government policies will affect different social and economic sectors of Brazil's economy.

## SECTION FIVE: OUTLINE OF STUDY

Chapter Two reviews the literature on science, technology, and development, focusing on the implications of technology choice upon socioeconomic development. Chapter Three examines how the alternative fuel industry fits into Brazil's socioeconomic structure. It details the development of the ethanol industry. Chapter Four presents the ways in which the alternative fuel program has affected employment and distribution. It describes two different technologies used to produce ethanol, as well their employment and distributional implications. Chapter Five presents a cost assessment of ethanol production. It covers ethanol production costs and several evaluations of the ethanol program. Chapter Six explains the SAM-based methodology that is used to measure and evaluate the direct and indirect employment and income distributional effects of Brazil's ethanol industry. It also describes the Brazilian SAM in detail. Chapter Seven presents the empirical findings of the data analysis. Chapter Eight discusses the results in light of energy policy formulation within the context of socioeconomic development planning.

# CHAPTER TWO

## REVIEW OF LITERATURE

The rationale of this study is to determine whether local labor-intensive technologies better contribute to the development process than capital-intensive technologies. The research hypotheses investigate the socioeconomic and environmental effects of several labor-intensive and capital-intensive technologies to assess which type of technology provides greater employment, improves income distribution, utilizes less conventional energy, and lowers greenhouse gas costs. To that end, the results of this research will contribute to the literature on science, technology, and development, especially technology choice and its social and economic consequences. Section one outlines the choice of technology debate. Section two presents empirical data on the employment and income distribution effects of industrialization between 1960 and 1990. Section three discusses the current evidence of technology choice using the same analytical framework as this research, i.e., the social accounting matrix model.

SECTION ONE: TECHNOLOGY CHOICE DEBATE

How does technology affect development in third world countries? Numerous studies illustrate its positive and negative contributions. It is now generally agreed that technology is not neutral and the results of empirical research show that technology can have deleterious socioeconomic consequences. Technology can also affect the underlying relationships of the entire economic system and ultimately impact a country's development path. Hence, development economists are reexamining more rigorously the relationship between technology and development to better understand the direct and indirect ramifications of technology choice.

Technology choice is critical to the development process because capital-intensive techniques and labor-intensive techniques have different socioeconomic linkages within the economy. These differences have a profound effect on the underlying relationships of the entire economic system and ultimately on the country's development strategy.

The technology choice debate focuses on the implications of choosing between alternative techniques of production. The general debate is between proponents of modern technologies, which are relatively capital-intensive, and advocates of traditional technologies, also known as intermediate, alternative and local technologies, which are relatively labor-intensive. The central argument revolves around the relationship of capital accumulation to investment and growth, and the tradeoff between current and future consumption. The resolution to this debate is important because the choice between modern and traditional technologies suggests radically different policy options. If modern technologies are chosen, then policies which encourage capital-intensive techniques are adopted, for example, lowering interest rates and currency revaluation. If traditional technologies are preferred, then government policies such as increased interest rates, tax incentives for labor-intensive techniques, and subsidies, are implemented. This research contributes to this debate by evaluating the employment and income effects of capital-intensive and labor-intensive technologies in the agriculture, manufacturing, energy, and service sectors.

A. Capital-Intensive Technology Argument

From the 1940s through the early 1960s, the conventional means of economic development was the introduction of capital-intensive technologies. These technologies were supposed to trigger the "trickle-down" effect and improve labor productivity, which in turn would lead to increased wages, salaries and greater profits. Higher wages and salaries were to encourage rising effective demand and result in greater expenditures in both existing and new markets. Greater profits were to permit increased retained earnings and increased investment. This strategy rewarded a higher growth rate to firms investing in capital-intensive technologies and expanded opportunities to those meeting the needs of wealthier workers. The socioeconomic results from the introduction of capital-intensive technologies were mixed. There was economic growth and employment, but the distribution of benefits was uneven.

Proponents of capital-intensive technologies argue that modern technologies are necessary for economic growth, because they are superior sources of capital accumulation, and contribute to investment which in turn leads to economic growth. While the resulting income distribution favors the high-income groups, it is their savings which expand the productive base and increase output. It is theorized that initially income inequality worsens; however, after a certain level of capital accumulation is achieved, there will be a spill-over effect. This inequality is temporary and will be reduced when labor is absorbed into the modern sector. As labor becomes scarce, wages will increase and income inequality will improve. Advocates of capital-intensive technologies point to the success of the Marshall Plan in the reconstruction of post-war Europe and to the historical experience of industrialized countries. This theory focuses on economic growth and is the basis of growth theory and modernization theory. It is supported by Polak, Buchanan, Kahn, Galenson and Leibenstein, Rostow, Kaldor, and Mellor. [33]

[33] J.J. Polak, "Balance of Payments Problems of Countries Reconstructing with the Help of Foreign Loans," *Quarterly Journal of Economics* 57 (1943): 218; Norman S. Buchanan, *International Investment and Domestic Welfare: Some*

Critics of this view say the major problem with the introduction of capital-intensive technologies is that it does not allow for important differences between developing countries and Europe. Developing countries do not have a shortage of laborers, an established infrastructure, a highly educated population, sufficient capital base and financial systems, or market and distribution systems. There is a mismatch of the needs of the developing country and the means for helping them achieve their development objectives.

During the 1960s, increasing divergences between the modern and traditional sectors were observed. This phenomenon of the "dual economy," i.e., the situation where the modern sector is largely unconnected to traditional preindustrial sectors, was imputed to capital-intensive technologies. The dual economy's failure to employ surplus labor and maldistribution of income challenged development economists to question the relationship between capital-intensive technologies and development.[34]

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*Aspects of International Borrowing and Lending in the Post-War Period* (New York: Holt and Company, 1945), 24; Alfred E. Kahn, "Investment Criteria in Development Programs," *Quarterly Journal of Economics* 38 (1951): 39; Walter Galenson and Harvey Leibenstein, "Investment Criteria, Productivity, and Economic Development," *Quarterly Journal of Economics* 69 (1955): 351; W.W. Rostow, "The takeoff into self-sustained growth," *Economic Journal* 66 (1956): 25-48; Nicholas Kaldor, *Strategic Factors in Economic Development* (Ithaca, NY: Cornell University, 1963), 11; and J.W. Mellor, *The New Economics of Growth: A Strategy for India and the Developing World* (Ithaca, NY: Cornell University, 1976).

[34]W.A. Lewis, "Economic development with unlimited supplies of labour," *Manchester School of Economics and Social Studies* 22 (1954): 139-191; G. Ranis and J. Fei, "A theory of economic development," *American Economic Review* 51

E. F. Schumacher criticized the introduction of capital-intensive technologies. He observed that many technologies which were transferred from industrialized countries exacerbated development problems of developing countries and led to misuse of scarce resources and difficult adjustment costs, as well as an overall worsening of welfare for the developing country, notably the poor.

B. Labor-Intensive Technology Argument

E.F. Schumacher was the first to advocate the use of traditional labor-intensive technologies as a means to achieve social and economic development in his book *Small Is Beautiful: Economics As If People Mattered*. He espouses the idea that simple technologies can alleviate unemployment and low productivity within existing socioeconomic structures and at the same time improve income inequality. He sets out four propositions:

> First, that workplaces have to be created in areas where people are living now and not primarily in the metropolitan areas into which they tend to migrate. Second, that these workplaces must be on average, cheap enough so that they can be created in large numbers without this calling for an unattainable level of capital formation and imports. Third, that the production methods employed must be relatively simple, so that demands for high skills are minimized, not only in the production process itself, but also in matters of organization, raw material supply, financing marketing, and so forth. Fourth, that production should be mainly from local materials and mainly for local use.[35]

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(1961): 533-565; D. Jorgenson, "The development of a dual economy," *Economic Journal* 71 (1961): 309-334.

[35]E.F. Schumacher, *Small is Beautiful: Economics As If People Mattered* (London: Harper and Row Publishers, 1973), 165.

There are additional characteristics of labor-intensive technologies. The production process is smaller scale; it includes the production of a simpler product designed for lower income consumers, or one that is suitable as an input into other local products or processes;[36] it is designed to be compatible with the preservation of nature using renewable, rather than non-renewable, resources.[37]

Proponents of labor-intensive technologies recommend that the choice of technology be based on the factor endowment of an individual country. This theory argues for labor abundant countries to adopt technologies that help increase employment, raise the productivity of those involved in traditional sectors, and produce goods for local consumption using indigenous resources. It further argues that this process will lead to greater income distribution and improved welfare, especially for the poor. This view rejects the idea that capital accumulation alone leads to growth, thence to development, i.e., the "trickle-down" approach to development; and instead ascribes to a strategy of redistribution with growth from the bottom-up.

Examples in the literature illustrate that the adoption of the traditional technology over the modern technology does indeed generate greater employment

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[36]Frances Stewart, *Macro-Policies for Appropriate Technology in Developing Countries* (Boulder, CO: Westview Press, 1987), 3.

[37]Harvey Brooks, "A Critique of the Concept of Appropriate Technology," in *Appropriate Technology and Social Values - A Critical Appraisal*, ed. FA. Long and

and increased income equality. The International Rice Research Institute has developed tools for small farmers which have resulted in tens of thousands of hand threshers being used in Thailand and the Philippines.[38] In Bangladesh, half a million manually operated pumps have increased incomes and improved the health of at least a million people.[39] In Chile, the Center for Studies in Appropriate Technology in coordination with local organizations developed energy-efficient insulated cooking pots which yield a 50% savings in cooking fuel.[40] In South Asia, areas susceptible to drought utilize traditional irrigation systems like hill-side tanks to improve irrigation and increase agricultural yields. Furthermore, a United Nations report on industry in the 1980s, which looked at employment and productivity within the manufacturing sector, found that, "in most developing countries, growth of output has been closely associated with reliance on relatively labor-intensive technologies."[41]

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A. Oleson. (Cambridge: Ballinger Publishing Company, 1980), 64.

[38]Frances Stewart, "The Case for Appropriate Technology: A Reply to R.S. Eckaus," *Issues in Science and Technology* (Summer 1987): 104.

[39] Ibid.

[40] M. Baquedano, "Socially appropriate technologies and their contributions to the design and implementation of social policies in Chile," in *Social Policy from the Grassroots: Nongovernmental Organizations in Chili* ed., C. Downs, G. Solimano, and L. Zuniga (Boulder: Westview, 1989), 135-48.

[41]United Nations, *Industry in the 1980s: Structural Change and Interdependence* (New York: United Nations, 1985), 130.

While empirical evidence demonstrates that the adoption of labor-intensive techniques may alleviate unemployment and may reduce inequality, investment in these technologies has been disappointing. Beder attributes this to "powerful vested interests supporting existing technologies as well as institutional and professional structures that have evolved alongside those technologies."[42] Ranis, Pack, Morawetz, Forsyth, Stewart, Willoughby, US Office of Technology Assessment, and Massaquoi identify government policies as the catalyst for selecting labor-intensive technologies.[43] The most recent discussion in the literature focuses on the

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[42]Sharon Beder, "The Role of Technology in Sustainable Development," *IEEE Technology and Society Magazine* Winter (1994): 17.

[43]Gustav Ranis, "Industrial Sector Labor Absorption," *Economic Development and Cultural Change* 21, no. 3 (April, 1973): 38; Howard Pack, "The substitution of labor for capital in Kenyan manufacturing," *Economic Journal* 86 (March 1976): 45; David Morawetz, "Employment Implications of Industrialisation in Developing Countries: A Survey," *Economic Journal* (September 1974): 530; David J.C. Forsyth, "Government Policy, Market Structure and Choice of Technology in Egypt" in *Technology, Institutions and Government Policies*, ed. J. James and S. Watanabe (New York: St. Martin's Press, 1985), 137-186; Frances Stewart ed., Macro-Policies for Appropriate Technology in Developing Countries, (Boulder, CO: Westview Press, 1987), 272; see also Frances Stewart, *Technology and Underdevelopment*, (Boulder, CO: Westview Press, 1977); Kelvin Willoughby, *Technology Choice: A Critique of the Appropriate Technology Movement* (Boulder, CO: Westview Press, 1990), 309-311; U.S. Congress, Office of Technology Assessment, Fueling Development: Energy Technologies for Developing Countries, OTA-E-516, (Washington, D.C.: U.S. Government Printing Office, April, 1992), 8; Joseph Massaquoi, "The Effect of Some Sectoral Development Policies on Technology - The Case of the Informal Sector," in *Technology and Developing Countries: Practical Applications, Theoretical Issues*, ed. Richard Heeks (London: Frank Cass & Co. 1995), 179.

importance of macro-policies within a country's political environment. Frances Stewart proposes:

> [I]f government policies deal with the objectives of decision makers, access to resources, nature of markets, and the availability of technology; within the political economy of each country, ...then,...as small farmers and the small-scale industrial sector develop in strength, they also acquire political strength. A cumulative process may then be set in motion which from small beginnings, results in a political economy favoring traditional technologies.[44]

The choice of technology debate continues to reveal the macroeconomic objectives of policymakers. At the micro level, evidence exists which show that the adoption of labor-intensive technologies does indeed in some cases provide greater employment and improve income inequality than capital-intensive technologies. However, macro projects require large investments in infrastructure which are by nature capital intensive. Is industrialization by labor-intensive technologies possible? The next section analyzes the employment and income distribution associated with industrialization between 1960 and 1990.

## SECTION TWO: INDUSTRIALIZATION

The Industrial Revolution began first in England in the eighteenth century with the use of steam power, innovations in the cotton textile industry, and the utilization of large quantities of coal and iron. Worldwide industrialization followed. It developed steadily in France in 1830 and in Germany in 1850; its boom period in

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[44]Stewart, *MacroPolicies for Appropriate Technologies*, 297.

the US occurred between 1860 and 1890. The Europeans introduced the development of industries in India, China, and Japan at the end of the nineteenth century and the beginning of the twentieth century. The Industrial Revolution continues throughout the world and is marked by significant social and economic structural changes.

One of the notable changes associated with the transition from an agricultural society to a modern industrial society is mechanization, which in turn has led to greater economic specialization and mass production. Worldwide output and incomes have increased dramatically in many parts of the world since World War II. The following subsections examine the employment and income distribution effects of recent industrial development.

A. Industrialization and Employment

Since the Industrial Revolution, there is the perception that technological progress has led to unemployment. While technological innovations have created unemployment in the short run, the vast productivity increases of the last two centuries suggest that there is no long-term crowding out effect from technology to unemployment.[45] However, Erikksson finds that there is a trade-off between growth and employment. He states that if the exogenous changes get larger and drive

[45]Clas Eriksson, "Is There A Trade-Off Between Employment and Growth," *Oxford Economic Papers* 49 (1997): 77.

interest rates up, then unemployment rises. On the other hand indirect changes in the growth rate due to lower interest rates e.g. lower capital tax or unemployment benefits, will improve employment. The policy implication is that in order to increase both growth and employment rates, one should improve incentives.[46]

Empirical evidence shows that average annual growth rates in industrial employment persistently lag behind average annual industry growth rates. Gustav Ranis highlights a report which identifies the employment concern:

> [E]ven where countries have been growing at 5 or 6% annually in real terms...industrial sector growth rates of 8 to 10% annually have been accompanied by labor absorption rates of only 2 to 3%.[47]

Table 3 provides the average annual growth rates for industrial employment and industry growth, as well as the labor elasticity coefficients (i.e., employment growth per industry output growth). It shows that overall industrial gross domestic product (GDP) growth and industrial employment growth are positively correlated; however, for the most part, labor elasticity coefficients are less than one between 1960 and 1990. The inelastic labor elasticity coefficients suggests that there is not much evidence of the "trickle-down" effect or at least labor-intensive industrialization.

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[46] Ibid.

[47] Gustav Ranis, "Industrial Sector Labor Absorption", 38.

Table 3. Average annual growth in the industry sector (Ind) and industry employment (L) and labor/industry (L/Ind) elasticity between 1960-1990, percentage.

| Country | 60-70 Ind | L | L/Ind | 70-80 Ind | L | L/Ind | 80-90 Ind | L | L/Ind |
|---|---|---|---|---|---|---|---|---|---|
| Germany | 5 | 1 | .18 | 3 | 1 | .23 | 2 | 1 | .27 |
| Japan | 11 | 4 | .23 | 5 | 2 | .29 | 4 | 1 | .28 |
| US | 4 | 2 | .47 | 3 | 2 | .70 | 3 | 1 | .39 |
| Ireland | 4 | 2 | .31 | 4 | 2 | .43 | 3 | 2 | .69 |
| Brazil | 12 | 5 | .27 | 9 | 6 | .54 | 2 | 3 | 1.62 |
| Chile | 5 | 3 | .49 | 3 | 3 | 1.0 | 3 | 3 | 1.1 |
| Mexico | 7 | 5 | .60 | 7 | 6 | .76 | 2 | 4 | 2.81 |
| Egypt | 7 | 3 | .43 | 10 | 3 | .24 | 6 | 4 | .58 |
| Gabon | 12 | 3 | .17 | 7 | 7 | .94 | -3 | 6 | -2.89 |
| Nigeria | 16 | 3 | .11 | 8 | 4 | .40 | -1 | 4 | -5.18 |
| Tanzania | 7 | 5 | .69 | 4 | 7 | 1.94 | 1 | 6 | 6.39 |
| Zaire | 5 | 5 | .99 | -1 | 6 | -4.62 | 2 | 4 | 2.29 |
| India | 4 | 2 | .51 | 5 | 2 | .40 | 7 | 3 | .39 |
| Pakistan | 8 | 3 | .24 | 7 | 4 | .51 | 7 | 2 | .59 |
| Korea | 12 | 6 | .36 | 10 | 5 | .37 | 10 | 4 | .32 |
| Singapore | 10 | 3 | .26 | 11 | 5 | .29 | 7 | 2 | .16 |
| Thailand | 11 | 5 | .32 | 7 | 7 | 1.01 | 9 | 4 | .39 |
| China | na | na | na | 8 | 4 | .47 | 10 | 5 | .36 |

Source: United Nations, *Macroeconomic Data System* (New York: United Nations), 1993.

Table 3 also shows that between 1960 and 1970, industry growth significantly outpaced industry employment growth in most countries. For all countries except Zaire, the labor elasticity coefficients were less than one. Whileindustry growth was slower in the 1970s, employment growth was still lower than industry growth in all countries, except Chile, Tanzania, Thailand, and Zaire. However, labor elasticities improved in all cases except Egypt and India during this decade. In spite of the 1980s recession, industry growth, by and large, continued to be greater than industry employment growth except in Brazil, Mexico, Gabon, Nigeria, Tanzania, and Zaire. In these cases the labor elasticities were greater than one which suggests that the recession did not adversely affect industry employment. In addition, it suggests that industry utilized more labor-intensive technologies than capital-intensive technologies as these countries have surplus labor and less capital to invest in capital-intensive technologies. In any case, while these countries were the exception, they represent one third of the sample. This suggests that developing economies may be able to insulate their industry employment by the use of relatively more labor-intensive technologies.

Economic growth associated with industrialization did result in greater employment between 1960 and 1990. However, the data show that the gap between labor absorption rates and industry growth rates remains during times of economic expansion and recession. The employment elasticities over the 30 year period improved in all cases except Asia (India, Korea, Singapore, and China) and the US.

Given surplus labor and insufficient demand for output worldwide, technology choice will affect sustainable development in industrialized and developing countries alike. The next section examines how the benefits of economic growth were distributed.

B. Industrialization and Income Distribution

A recent United Nations study on the international distribution of world income finds that while the level of gross world product increased six fold between 1970 and 1989, income equality among countries deteriorated.[48] Figure 3 shows that, between 1970 and 1989, the average annual inequality growth rate increased by 0.21% based on the Gini index which is based on purchasing power parity conversion rates.[49] Why income inequality increases with industrialization is not clear.

One group of studies concludes that there is a tradeoff between growth and income equality. Kuznet's inverted U hypothesis states that income equality

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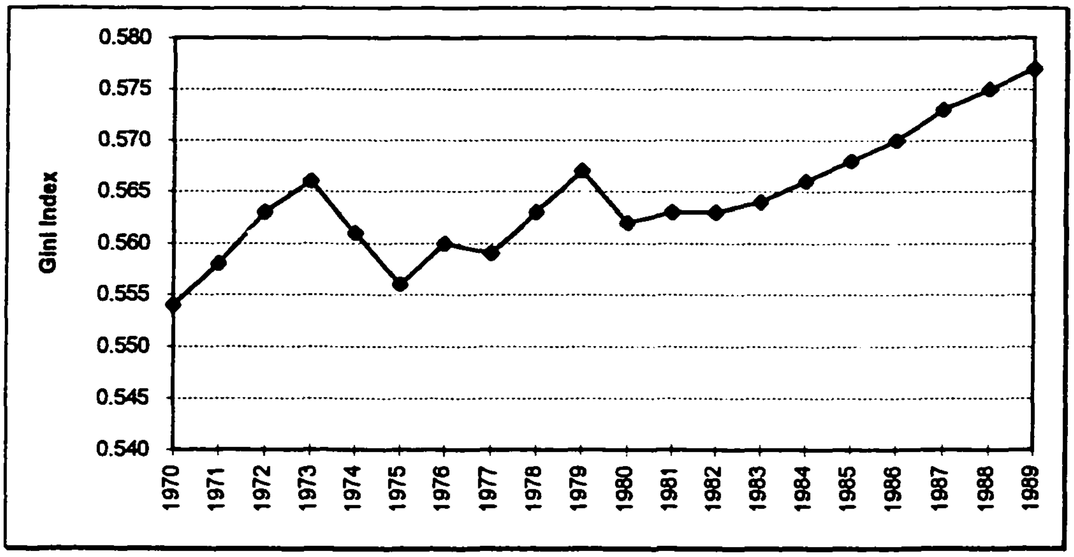
[48]United Nations, *Trends in International Distribution of Gross World Product* (New York: United Nations, 1993), 20, 25.

[49]The Gini index is an indicator of income inequality. It is a ratio of the area between the Lorenz curve and the complete equality line to the entire area between the complete equality line and the complete inequality line. The value of the Gini index will lie between zero (complete equality) and one (complete inequality). United Nations, *Trends in International Distribution of Gross World Product*, 29.

deteriorates during the early stages of economic growth and then improves during the later stages. This relationship is supported by Kuznets, Wells, Fishlow, Adelman and Morris, and Paukert.[50] Others argue that income distribution can affect

FIGURE 3. GINI INDEX OF GROSS WORLD PRODUCT: 1970-1989.




Source: United Nations, *Trends in International Distribution of Gross World Product* (New York: United Nations, 1993), 30.

the potential for industrial growth. Income inequality can limit the size of the domestic market which would negatively affect economic growth (Murphy, Shleifer and Vishny, and Galor and Zeira).[51]

[50]Simon Kuznets, "Quantitative Aspects of the Economic Growth of National Distribution of Income by Size," *Economic Development and Cultural Change* 11, no. 2 (1963): 1-79; J. Wells, "Distribution of Earnings, Growth, and the Structure of Demand in Brazil during the 1960s," *World Development* 2 (1970): 97-126; A. Fishlow, "Brazilian Size Distribution of Income," *American Economic Review* 62, no. 2 (1972): 391-402; Irma Adelman and C. T. Morris, *Economic Growth and Social Equity in Developing Countries* (Stanford, CA: Stanford University Press, 1973); F. Paukert, "Income Distribution at Different Levels of Development: A Survey of Evidence," *International Labour Review* 108 (1973): 97-126.

Another group of studies in the literature finds that the evidence does not link economic growth with income deterioration (Ahluwalia, Loehr and Powelson, Fields, Papanek and Kyn).[52] These authors state that on the basis of time series analysis, no direct relationship between growth and inequality exists. There are some who state that growth and equitable income distribution is possible. The East Asian model is given as an example to show that relatively equitable income distribution can be sustained throughout the rise from low-income to high-income status (Auty, Griffin, Lucas and Verry).[53]

While it is clear that industrialization has led to economic growth, the employment and income distributional effects are mixed. To better understand the underemployment and increasing income inequality requires an investigation of the

[51]K. Murphy, A. Shleifer, R. Vishny, "Industrialization and the Big Push," *Journal of Political Economy* 97, no. 5 (1989): 1003-1026; Galor and J. Zeira, "Income distribution and macroeconomics," *Review of Economic Studies* 60, no. 1 (1993): 35-52.

[52]M. S. Ahluwalia, "Income Inequality: Some Dimension of the Problem," in Chenery et. al., *Redistribution with Growth.* (London: Oxford University Press, 1974); William Loehr and John Powelson, *The Economics of Development and Distribution* (New York: Harcourt Brace Jovanovich, Inc, 1981), 127; Gary S. Fields, "Growth and Income Distribution," in *Essays on Poverty, Equity and Growth* ed. George Psacharopoulos (New York: Pergamon Press, 1991), 37; Gustav Papanek and Oldrich Kyn, "The effect on income distribution of development, the growth rate and economic strategy," *Journal of Development Economics* 23, no.1 (1986): 55-65.

[53]Richard M. Auty, *Patterns of Development: Resources, Policy and Economic Growth* (London: Edward Arnold, 1995), 260.

structure of production. In what ways does the choice of technique contribute to employment and income distribution objectives? Modeling based on the social accounting matrix methodology captures the effects of growth in different economic sectors in each socioeconomic sector of the economy.

## SECTION THREE: SAMS AND CHOICE OF TECHNIQUE

The SAM is a tool for planners to better understand the social and economic consequences of the development process. Its methodology is rooted in Francois Quesnay's *Tableau Economique*[54] with further extensions being done by its modern architect, Sir Richard Stone.[55] The SAM has been utilized since the mid 1970s and a body of literature exists to show the application of this methodology.[56] A number of country and regional SAMs exist that detail the interrelationships among the structure of production, the value added to the factors of production, and the income distribution by different socioeconomic groups as well as their corresponding consumption and savings patterns. The Brazilian SAM, built by Maria J. Willumsen[57]

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[54]Francois Quesnay, Tableau Economique, 1758.

[55] Richard Stone, "The Social Accounts from a Consumer Point of View" *Review of Income and Wealth* 12, no.1 (March 1966): 1-33.

[56]See Graham Pyatt and Jeffrey Round, *Social Accounting Matrices: A Basis for Planning* (Washington, D.C.: The World Bank, 1985).

[57]M.J.F. Willumsen, "The Social Accounting Framework as a Tool for Policy Analysis: The Case of Brazil" (Ph.D. diss., Cornell University, 1984).

and extended by Robert D. Cruz and Maria J. Willumsen,[58] is the basis of the current research.

Modeling based on a social accounting matrix (SAM) framework takes a multi-sectoral economy-wide approach to study the underlying relationships of development including that between growth and poverty. It can also assess the income and employment effects associated with a technology choice. Several studies using the SAM methodology classify the production of various products along dualistic technological criteria, namely the production of a good by a modern technology and a traditional technology. Many cases show that the traditional technology generates greater employment and income effects than the modern technology (Khan, Defourny and Thorbecke, Khan and Thorbecke, Svejnar and Thorbecke, James and Khan, and Leatherman and Marcouiller).[59]

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[58]Robert Cruz and M.J.F. Willumsen, "Wage Inflation, Fiscal Policies, and Income Distribution in Brazil," *Journal of Policy Modeling* 13, no.3 (1991): 383-406.

[59]Haider Khan, "Choice of Technology and Income Distribution" (Ph.D. diss., Cornell University, 1982); H. Khan, "Technology Choice in the Energy and Textile Sectors in the Republic of Korea," in *Technology and Employment in Industry: A Case Study Approach*, ed. A.S. Bhalla (Geneva, Switzerland: International Labour Office, 1985); J. Defourny and E. Thorbecke, "Structural Path Analysis and Multiplier Decomposition within a SAM Framework," *Economic Journal* 94 (1984): 111-136; H. Khan and E. Thorbecke, *Macroeconomic Effects and Diffusion of Alternative Technologies within a Social Accounting Matrix Framework: The Case of Indonesia* (Brookfield: Gower Publishing Co., 1988); J. Svejnar and E. Thorbecke, "Determinants of Technological Choice," in *Technology Choice and Change in Developing Countries: Internal and External Constraints*, ed. Barbara Lucas and Stephen Freedman (Dublin: Tycooly International Publishing Ltd., 1983);

Most recently, this modeling methodology has been used to analyze the impact of growth in different economic sectors on poverty (Khan, Thorbecke and Jung, and Lipton and Ravallion).[60] These studies point to the importance of sectoral patterns of growth on poverty. Thorbecke and Jung found that for Indonesia the agriculture and service sectors offer more to overall poverty alleviation than the industrial sectors. Khan found that in South Africa the mining and service sectors provide the greatest benefit to the rural and urban poor; in addition, the manufacturing sector has few direct linkages to poor African households.

SECTION FOUR: CONCLUSION

This chapter discusses the importance of technology choice to economic growth, employment, and income distribution. Advocates of capital-intensive technologies believe they are relatively more profitable, and in the long run provide greater growth because of increased productivity with its resultant rising earnings which in turn provides greater long term employment. Proponents of labor-intensive

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Haider Khan and Jeffrey James, "Technology Choice and Income Distribution," *World Development* 25, no. 2 (1997): 165; John Letherman and David Marcouiller, "Income Distribution Characteristics of Rural Economic Sectors: Implications for Local Development Policy, " *Growth and Change* 27 (1996): 434-459.

[60]Haider Khan, "Sectoral Growth and Poverty Alleviation: A Multiplier Decomposition Technique Applied to South Africa," forthcoming. E. Thorbecke and H.S. Jung, "A multiplier decomposition method to analyze poverty alleviation," Journal of Development Economics 48 (1996): 279-300; and M. Lipton and M. Ravillion, "Poverty and policy" Working paper WPS 1130 (Washington, D.C.: The World Bank, 1993).

technologies believe that employment and income distribution concerns must be foremost on the planners' agenda. In doing so, labor-intensive technologies will contribute to income distribution, employment, as well as the long term growth objectives which will provide both economic and social stability.

The question is, do labor-intensive technologies truly offer the employment and income distribution benefits to address the persistent unemployment and income inequality of so many countries? If so, then efforts need to be made to encourage the adoption of labor-intensive technologies; if not, then perhaps growth objectives need to be reevaluated and fostered to assist developing countries achieve their development objectives. It seems that capital-intensive technologies may enhance rapid growth today at the expense of some employment and maldistribution of benefits. Additionally, labor-intensive technologies may offer greater income distribution and employment today than in the future. The planner's priority and the situation in each developing country will dictate which scenario is the case: employment and income distribution versus economic growth and some employment. There is no definitive answer to meet the needs of developing countries. The planner must weigh either higher incomes and fewer jobs today or more jobs and less equal distribution of benefits today.

# CHAPTER THREE

# BRAZIL'S ALTERNATIVE FUEL PROGRAM

Brazil has the largest alternative fuel program worldwide. The national program, commonly known as *Proalcool*, came about because of prevailing domestic and international circumstances confronting Brazil's political economy. This chapter documents the linkages between Brazil's alternative fuel industry and its socioeconomic structures. Section one provides a thumbnail sketch of Brazil, positioning the alternative fuel industry within the context of Brazil's economic development. Section two summarizes the four phases of the *Proalcool* program. Sections three and four detail the evolution of the public and private sector participation in the ethanol industry. Section five concludes with a description of Brazil's household energy consumption.

## SECTION ONE: BRAZIL AND ITS ALTERNATIVE FUEL INDUSTRY

### A. Brazil

Brazil is one of the largest countries in the world. The World Bank ranks Brazil fourth in terms of land mass, fifth in population, and eighth in economic size.[61]

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[61]World Bank, *1992 World Development Report: Development and the*

- 47 -It is classified as an upper middle-income country with a per capita income of $4,700 ($5,400 at purchasing power parity).[62] The annual growth rate of per capita GDP averaged 4.6% between 1973 and 1980, but was -0.4% between 1980 and 1993. Per capita income fell during the latter period in spite of a sharp slowing down of population growth, to only 1.9%. There were negative GDP growth rates in 1983, 1988, 1990, and 1992. Table 4 shows Brazil's economic growth rate. inflation and investment between 1978 and 1993.[63] In 1990, Brazil's external debt exceeded $116 billion.

Table 4. Brazil: growth. inflation and investment.

| Time Periods | Growth rate (%) | Inflation rate (%) | Investment growth rate (%) | Investment ratio (%)[a] |
|---|---|---|---|---|
| 1978 | 4.9 | 40.8 | 4.8 | 23.52 |
| 1979-1980 | 8.5 | 93.0 | 8.6 | 23.22 |
| 1981-1982 | -1.7 | 97.4 | -9.5 | 20.80 |
| 1983 | -2.9 | 211.0 | -16.3 | 17.22 |
| 1984-1986 | 6.9 | 161.7 | 10.0 | 17.17 |
| 1987-1989 | 2.2 | 933.8 | -1.7 | 17.18 |
| 1989-1991 | -0.4 | 1098.7 | -4.5 | 15.73 |
| 1990-1993 | -0.3 | 1240.8 | -3.7 | 14.69[b] |
| 1991-1993 | 1.2 | 1170.2 | -1.2 | 14.40[b] |

"Reprinted from *World Development* 24, no. 2, M. Abreu *et al.*, Brazil: Widening the Scope for Balanced Growth. 241-254, © (1996). with permission from Elsevier Science."

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*Environment* (New York: Oxford University Press. 1992), 219, 223.

[62]*The Economist*. "Reforming Brazil: Is it for real?" (May 17, 1997): 38.

[63]M. Abreu, D. Carneiro, and R. Werneck, "Brazil: Widening the Scope for Balanced Growth," *World Development* 24, no. 2 (1996): 241, 243.

Brazil's economy is highly politicized with the federal government strongly influencing economic development. Brazil's industrialization process has predominately centered on making its large domestic market self-reliant through an import substitution strategy involving state-owned industry, significant tariff and non-tariff protection, and economic regulation. Import substitution was the goal of Brazil's economic policies between 1946 and 1964, when it achieved an all time low import ratio of 6%.[64] Then an export-oriented trade strategy was followed between 1964 and 1973. The first energy crisis of 1973-74 precipitated a renewed import substitution drive which favored mineral exploitation and the use of public funds to survey mineral deposits, especially crude oil and non-iron ores.[65] Import protection with export subsidies and aggressive devaluations were used to address the balance of payments problems in the 1980s.

Brazil's economic policies have shifted since the 1990 democratic elections. The civilian government policies encouraged trade liberalization, privatization and export promotion. The government replaced all quantitative barriers with tariffs and in 1992 established a new tariff schedule, with a maximum of 35% that was enacted

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[64] World Bank, *Brazil: Industrial Policies and Manufactured Exports* (Washington, D.C.: The World Bank, 1983), vi.

[65] Antonio Brandao and J.L. Carvalho, *Trade, Exchange Rate, and Agricultural Pricing Policies in Brazil* (Washington, D.C.: The World Bank, 1991), 2.

in early 1994, and bound in the General Agreement on Tariffs and Trade.[66] The country's average import tariff was brought down from 51% in 1988 to below 14% in 1996.[67] In March 1991, Brazil signed the Asuncion Treaty with Argentina, Uruguay, and Paraguay, creating the Mercosul: a common market for goods, services and factors among those countries, which began in 1994. Brazil's success with integrating liberalization will depend on the ability of the economy to absorb lower aggregate domestic demand and possible regional or sectoral unemployment resulting from import competition.[68]

In mid-1994, President Cardoso introduced the real plan named after the new currency in order to stabilize prices. In 1996, inflation was 10%, the lowest inflation rate in Brazil since the 1950s.[69] The achievement of such low inflation has had three major effects in Brazil because inflation was so firmly institutionalized:

> First, the country has started to reverse discrimination against the poor. The United Nations Economic Commission for Latin America reckons that at least 8 million people were lifted out of poverty between 1993 and 1995 (though perhaps a third of Brazilians remain below the official poverty line). Second, greater price stability has enable firms for the first time in a generation to think about the medium term. Many have opted to modernise themselves by teaming

[66]Winston Fritsch, "Brazil Strengthens Its Hand on Trade," *International Economic Insights* (July/August 1992), 7.

[67] Abreu *et al.*, "Brazil: Widening the Scope for Balanced Growth," 244.

[68]Ibid.

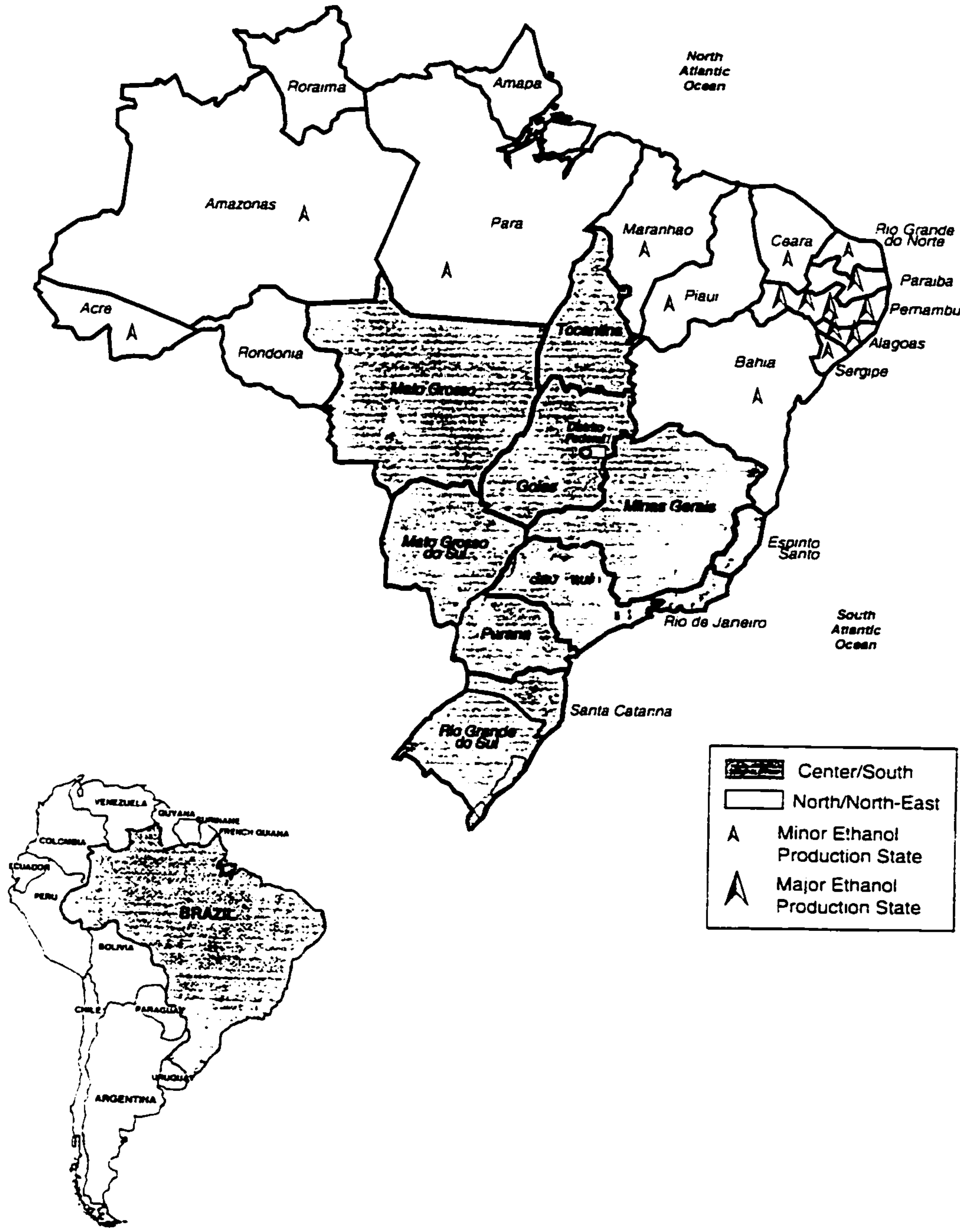
[69]*The Economist*, "Reforming Brazil: Is it for real?" 39.

> up with foreigners. Third, relative macro-economic stability has increased growth and triggered a consumer boom. Sales of packaged foods, consumer durables and cars have rocketed, as millions of new consumers have entered the market.[70]

Brazil is a dualistic economy with two major macro regions, the richer center-south and the poorer north/northeast. Figure 4 presents a map of Brazil and shows the two macro-regions and ethanol producing areas. The center-south is subdivided into three regions with the following states and territories in parentheses: south (Parana, Santa Catarina, and Rio Grande do Sul), southeast (Minas Gerais, Espirito Santo, Rio de Janeiro, and Sao Paulo), and center-west (Mato Grosso and Goias). The north/northeast comprises the north (Rondonia, Acre, Amazonas, Roraima, Para, and Amapa) and the northeast (Maranhao, Piaui, Ceara, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas, Sergipe, and Bahia). This macro-regional classification is used by the government as a basis for national development planning, because of the huge disparity of income between the two macro-regions. The south-east and south are the richest regions, in absolute and per capita terms. The center-west is poorer in absolute terms and in development infrastructure, but because its population is very low and its per capita relatively high, it is considered part of the center-south. In the north/northeast, the north and most of the Amazon region are

[70]Ibid.

FIGURE 4. BRAZIL'S MACRO-REGIONS AND ETHANOL PRODUCING STATES.



poor and thinly populated while the northeast is heavily populated and the poorest region in the country on a per-capita basis.[71]

The social consequences of Brazil's political economy include regional differences in education, energy utilization, population, and economic development. Table 5 shows social and economic indicators for Brazil's northeast and southeast regions for 1960 and 1980.

Table 5. Social and economic indicators for two regions, 1960 and 1980, percent.

| Year | 1960 | | 1980 | |
|---|---|---|---|---|
| Brazil | Northeast | Southeast | Northeast | Southeast |
| Share of total population | 31.7 | 43.7 | 29.3 | 43.5 |
| Share of industrial value added | 6.9[a] | 79.2[a] | 8.1 | 72.6 |
| Share of domestic income | 14.4[a] | 65.0[a] | 11.6[b] | 63.5[b] |
| Illiterate | 65.7 | 36.7 | 52.9 | 21.5 |
| Households with electricity | 16.4 | 58.2 | 43.6 | 85.4 |
| Share of population in rural areas | 66.1 | 43.0 | 49.5 | 20.8 |
| Share of households with sewage | 6.1 | 40.4 | 18.2 | 63.5 |

a-data for 1959; b-data for 1975.

Source: IBGE. Anuario estatistico (1960, 1980) in Maddison and Associates. *The Political Economy of Poverty, Equity, and Growth: Brazil and Mexico* © (New York: Oxford University Press, 1992), 80.

[71]Ramesh Bhatia and Armand Pereira, *Socioeconomic Aspects of Renewable Energy Technologies* (New York: Praeger, 1988), 48.

The indicators reveal that the level of economic development and standard of living in the southeast region is considerably higher than the northeast region. In 1980, the per capita of the urban southeast was about two times greater than the national average. On the other hand, the rural northeast had a per capita income of about one-half the national average and one-fourth of that in the state of Sao Paulo.[72] The underlying socioeconomic situation was a contributing factor leading to the development of Brazil's alternative fuel program.

B. Brazil's Alternative Fuel Program

In Brazil, ethanol is produced from sugarcane, which is an important and longtime staple to the agricultural sector and economy.[73] Brazil's government has long promoted ethanol as a petroleum substitute.[74] During World War I, the use of ethanol was required in all gasoline and by 1923, ethanol production reached 150 million liters per year (3.18 PJ). The *1o Congresso Nacional sobre Aplicacoes Industriais do Alcool* (First National Congress on Industrial Applications of Alcohol)

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[72]Angus Maddison and Associates, *The Political Economy of Poverty, Equity, and Growth: Brazil and Mexico* (Washington, D.C.: The World Bank, 1992), 81.

[73]Sugar cane, introduced in 1534 by Portuguese colonizers, was the leading agricultural commodity until 1850. It continues to be a chief agricultural export. Antonio Brandao and Jose Carvalho, *Trade, Exchange Rate, and Agricultural Pricing Policies in Brazil*, 10-11.

[74]Nicholas Otto designed the first modern internal combustion engine in 1876 to run on fuel ethanol. Henry Ford's Model T also ran on ethanol as did most engines at the turn of the 20th Century.

proposed that an infrastructure be established to promote ethanol production and use.[75] In 1931, a federal decree mandated that ethanol (at least 5% by volume) be added to gasoline and established guidelines for its transportation and commercialization in order to increase demand for sugar during the worldwide depression. By 1941, ethanol production reached 650 million liters (13.8 PJ).[76] The mandated use of ethanol continued with the exact proportion of ethanol varying according to the availability of sugarcane. Figure 5 shows the percentage of anhydrous ethanol (mixing gasoline with ethanol) in gasoline between 1939 and 1989. Currently, 22% ethanol by volume is required to be included in each liter of gasoline sold.

Ethanol as a transportation fuel became important in 1956, when the government pursued an industrialization strategy based on the automotive industry.[77] Between 1967 and 1974, automobile output quadrupled, and by 1974 Brazil had 4 million cars and 1.4 million trucks and buses. During the same period, annual petroleum consumption nearly doubled to about 11.9 billion liters per day (2.52 PJ).[78] Highway travel was emphasized over railroads and mass transit.

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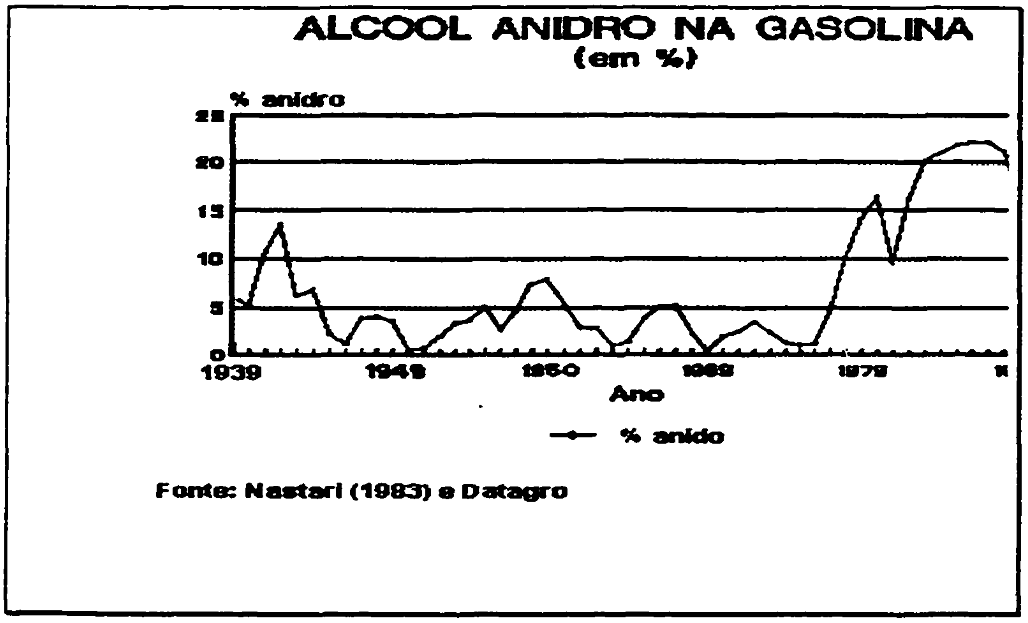
[75]Nastari, "The role of sugarcane in Brazil's history and economy," 112.

[76]Goldemberg *et al.*, "The Brazilian Fuel Alcohol Program", 841.

[77]Marc Levison, "Alcohol Fuels Revisited: The Costs and Benefits of Energy Independence in Brazil," *The Journal of Developing Areas* 21 (April 1987) 243-244.

FIGURE 5. PERCENTAGE OF ETHANOL IN GASOLINE.




Source: Plinio Nastari, personal correspondence, 1992.

By the 1970s, Brazil was importing from 80% to 85% of its domestically consumed petroleum compared to 20% in the early 1950s.[79] In 1972, before oil prices quadrupled, Brazil spent $600 million per year on petroleum.[80] In 1974, Brazil's oil import bill grew to $3.2 billion, or 39.5% of total exports.[81] By 1978,

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[78]Sperling, *New Transportation Fuels*, 73.

[79]CENAL, *The National Alcohol Program: Proalcool* (Brasilia, Brazil: National Executive Commission of Alcohol, 1988), 5.

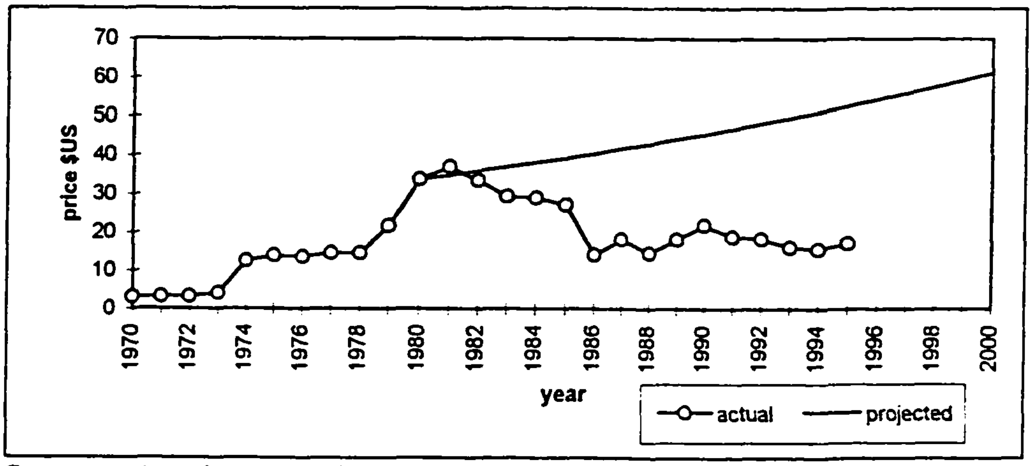
[80]Ibid., 73.

[81]Levison, "Alcohol Fuels Revisited," 243.

petroleum imports increased to over $4 billion and continued increasing into the early 1980s.[82]

Oil prices were key to the development of Brazil's alternative fuel program. Oil price projections of the World Bank in 1980 were forecast to increase at about 3% per year, to the end of the century. Figure 6 shows this forecast, along with the evolution of actual crude oil prices between 1970-2000.[83]

FIGURE 6. ACTUAL AND PROJECTED CRUDE OIL PRICES 1970-2000, $/BARREL OF OIL.




Source: American Petroleum Institute, *Basic Petroleum Data Book*, 17, no. 1 (January 1997): Section VI, Table 3.

Before the energy crises of the 1970s, ethanol was viewed as a gasoline extender; afterwards its role changed to be a gasoline substitute. The major factors

[82]Sperling, *New Transportation Fuels*, 73.

[83]World Bank, *Project Performance Audit Report*, (Washington, D.C.: The World Bank, 1990), 8-9.

contributing to the expanded use of an alternative transportation energy, was the Organization of Petroleum Exporting Countries' oil price increases and the consequential foreign exchange requirements for oil imports. Two additional factors were critical to the evolution of ethanol as a transportation fuel: Brazil's sugar supply and its foreign debt service.

The prevailing international and domestic circumstances facing the Brazilian sugar industry in the early 1970s largely contributed to the development of an alternative fuel program based on sugarcane. In 1971, the Brazilian Institute of Sugar and Alcohol (IAA) initiated a major sugar modernization program to capitalize on the expectations of expanded sugar export markets following the US embargo of Cuban sugar.[84] Sugar is one of Brazil's most important agricultural exports and is exported as a processed good (brown or refined sugar).[85] It is consistently among Brazil's top ten manufactured exports.[86]

Figure 7 shows that export earnings varied greatly due to volatile sugar prices, particularly between 1974 and 1976. World prices fluctuated drastically, from

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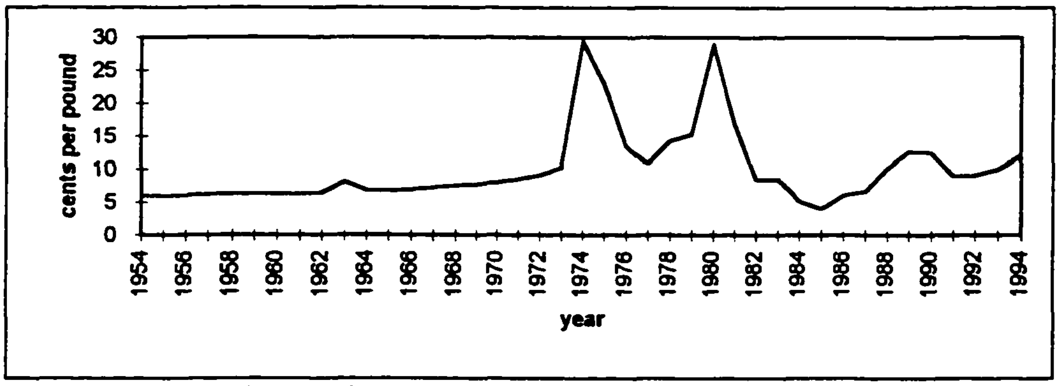
[84]World Bank, *Project Performance Audit Report, Brazil: Alcohol and Biomass Energy Development Project*, 3.

[85]Antonio Brandao and J.L. Carvalho, *Trade, Exchange Rate, and Agricultural Pricing Policies in Brazil*, 105.

[86]World Bank, *Trends in Developing Economies 1991* (Washington, D.C.: The World Bank, 1991), 58.

monthly highs of 57 cents per pound in 1974 to 9.5 cents per pound in 1976. This corresponded to sugar exports valued at $1.3 billion, or 16.6% of the value of total merchandise exports in 1974 to $306 million, or 3%, of total merchandise exports in 1976.[87] By 1985, sugar traded at 3 cents per pound and began increasing due to reduced stocks and supply deficits. In 1990, world sugar prices fell from 15 cents a pound down to 10 cents. In 1995, sugar was trading at 12 to 15 cents a pound.

FIGURE 7. WORLD SUGAR PRICES (1954 TO 1994).




Source: Knight-Ridder Financial/Commodity Research Bureau, *CRB Commodity Yearbook* (New York: John Wiley & Sons, Inc., 1996), 271.

An ethanol transportation fuel, based on sugarcane, benefited the sugar industry by providing an additional value-added market for sugarcane. This was important for several reasons. First, it reduced sugar's vulnerability to widely fluctuating world prices through an alternative use for sugarcane. Second, it reduced the economic risk of modernizing the sugarcane industry. Third, it protected and

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[87]World Bank, *Brazil: Economic Memorandum* (Washington, D.C.: The World

restored the political influence of sugar producers as they advanced the nation's import-substitution objectives. The option to sell sugarcane on the world market or to convert it into a transportation fuel stabilized and revitalized the sugar industry.

Table 6. Brazil's oil imports and trade balance, millions of dollars.

| Year | Exports | Imports | Foreign Debt | Oil Imports | Oil Imports Accumulated | Oil Imports/ Exports (%) |
|---|---|---|---|---|---|---|
| 1971 | 2.900 | 3.200 | | 280 | | 9.7 |
| 1972 | 4.000 | 4.200 | 9.500 | 380 | 660 | 9.5 |
| 1973 | 6.200 | 6,200 | 12.600 | 720 | 1.400 | 11.6 |
| 1974 | 8,000 | 12,600 | 17.200 | 2,800 | 4,200 | 35.0 |
| 1975 | 8.700 | 12.200 | 21.200 | 2,750 | 7.000 | 31.6 |
| 1976 | 10.100 | 12.300 | 26.000 | 3,460 | 10.400 | 34.3 |
| 1977 | 12.000 | 12.000 | 32.800 | 3.660 | 14.100 | 30.5 |
| 1978 | 12.700 | 13.700 | 43.500 | 4,090 | 18.200 | 32.2 |
| 1979 | 15.200 | 18.000 | 49.900 | 6.190 | 24.300 | 40.7 |
| 1980 | 20.100 | 23.400 | 53.800 | 9,370 | 33.700 | 46.6 |
| 1981 | 23.300 | 22.100 | 61.400 | 10.600 | 44.300 | 45.5 |
| 1982 | 20.200 | 19.400 | 70.200 | 9.600 | 53.900 | 47.5 |
| 1983 | 21,900 | 15.400 | 84.200 | 7,800 | 61.700 | 35.6 |
| 1984 | 27.000 | 13.900 | 100.200 | 0 | 0 | 0 |
| 1985 | 25.600 | 12.200 | 97.900 | 0 | 0 | 0 |

Source: Jose Goldemberg. *Energy for a Sustainable World*, © (New York: John Wiley & Sons,1988) 240. Reprinted by permission of John Wiley & Sons, Inc.

Brazil's external debt service also forced government leaders to seek ways to reduce its foreign debt, particularly its oil imports. Oil imports were a major source of Brazil's foreign debt problem. Table 6 shows the impact of oil imports on

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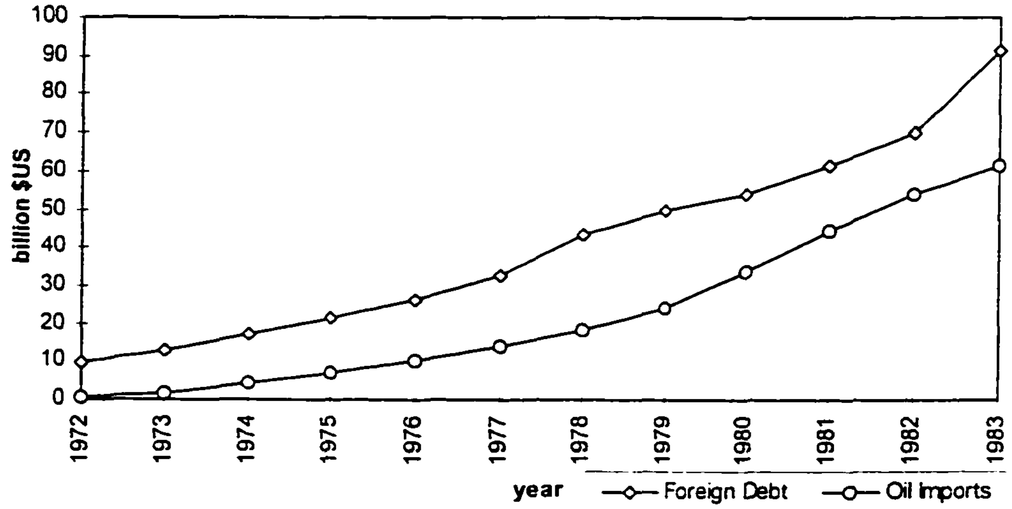
Bank, 1984), 254.

Brazil's economy. For example, 47% of export earnings were used to pay for oil imports in 1982.

The external debt did not affect the economy until the early 1980s, with the second oil shock and the higher international interest rates. This situation was compounded by the lack of foreign loans and capital flight from Brazil in 1982. The London Interbank Offer Rate (LIBOR) dollar rate increased from an average of 9.4% in 1978 to a peak of 19.5% in March 1980.[88] Figure 8 shows that Brazil's foreign debt can be attributed in large part to the accumulated oil bill since 1973.

FIGURE 8. EVOLUTION OF BRAZIL'S FOREIGN DEBT AND OIL IMPORT INFLUENCE.




Source: Jose Goldemberg, *Energy for a Sustainable World.*© (New York: John Wiley & Sons, 1988), 241. Reprinted with permission from John Wiley & Sons, Inc.

[88]Ibid., 5. LIBOR is the London Interbank Offer Rate, which is the interest that banks in London pay to attract deposits from other banks for six months. B.D. Nossiter, *The Global Struggle for More* (New York: Harper & Row, 1987), 7.

The energy crisis, coupled with an abundant sugar supply and an increasing foreign debt service, prompted the government to adopt an alternative transportation fuel policy in 1975. On November 14, 1975, President Ernesto Geisel created *Proalcool* (the National Alcohol Program) primarily to save foreign exchange and to be energy self-sufficient. Other objectives included: stimulate rural employment, reduce regional income inequality, utilize surplus agricultural feedstock and foster a domestic research and development capability in distillation technology and machinery.[89] Brazil's program has been successfully implemented because of—and in spite of—the government's participation.

External factors, including instability in the world oil and sugar commodity markets and the resulting foreign debt service, drove the government's support of the alternative fuel program rather than market forces. The prevailing domestic factors were the trade and budget deficits. Thus, the government created *Proalcool* in order to address the country's fiscal and energy concerns and assisted in the development of the alternative fuel program.

SECTION TWO: *PROALCOOL* DEVELOPMENT PHASE HIGHLIGHTS

There are four phases of *Proalcool's* development: Phase I (1975-1978); Phase II (1979-1984); Phase III (1985-1989); and Phase IV (1990-present). This section describes the main features of each phase.

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[89]Plinio Nastari, "The Role of Sugarcane in Brazil's History and Economy," (Ph.D.

A. *Proalcool* Phase I (1975 to 1978)

Phase I started with a government decree to create a domestic ethanol industry. It was based primarily on the production of "gasohol," a mixture of up to 20% ethanol by volume. This period is characterized by an expanded production of predominantly anhydrous ethanol (mixing gasoline with ethanol) and hydrous (pure) ethanol (a neat alternative fuel). The government's primary objective was to save foreign exchange via gasoline substitution. This was accomplished by utilizing idle capacity at existing annexed distilleries of sugar plantations. The quadrupling of ethanol production occurred during this time because government policies provided significant incentives to producers. Large sugarcane plantations added distilleries and converted the cane to ethanol because of depressed sugar prices worldwide.

There were two key factors which limited the risks of this phase. First, automobiles normally fueled with gasoline did not require any engine modifications when using "gasohol" (anhydrous ethanol). Therefore, the spark-ignition engine market remained single engine and essentially single fueled, with ethanol replacing gasoline. Second, the opportunity value of the anhydrous ethanol was equal to that of the gasoline displaced; ethanol's lower energy content was partially offset by its higher octane number.

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diss., Iowa State University, 1983), 112.

B. *Proalcool* Phase II (1979 and 1985)

Phase II was the boom phase of the ethanol industry. The second oil crisis of 1979-80 prompted government policy makers to broaden *Proalcool's* objectives. Expansion was financed in part by the World Bank. In 1981, the World Bank approved a loan for $250 million to partially finance 67 ethanol distilleries.[90] This period is marked by four developments.

The first aspect of this phase was the decentralization of production and supply of ethanol. The aim was to encourage increased employment and raise incomes, especially in the rural areas. This was achieved through the participation of autonomous distilleries. The government provided incentives for the development and expansion of autonomous distilleries. Autonomous distilleries, located independently from sugar plantations and often in rural areas, were involved solely in ethanol production and received their sugarcane from small cooperatives.

The second development of this phase was the commercialization of neat ethanol-powered vehicles in late 1979. There were significant government incentives for the purchase of both neat ethanol-powered vehicles and fuel such that by 1980 these vehicles accounted for 73% of vehicle sales. The first neat ethanol-powered vehicles were simply gasoline-powered engines, modified to use ethanol. However,

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[90]World Bank, *Project Performance Audit Report: Brazil Alcohol and Biomass Energy Development Project* (Washington, D.C.: The World Bank, 1990), 55.

widespread problems with exhaust system corrosion and cold-starts occurred because of the materials' incompatibility with neat ethanol. In addition, unlicensed mechanics performed faulty ethanol conversions. Consumer acceptance of both ethanol and the new vehicles was undermined because no one could differentiate between factory produced ethanol vehicles and poorly retrofitted vehicles. This, combined with the fuel price increases from 40% to the 65% cap on ethanol, resulted in a sharp decline in neat ethanol vehicles to less than 10% of total vehicle sales by July 1981. The government renewed its commitment to the program by lowering alternative fuel prices to 59% of the gasoline price and by continuing to provide incentives to purchase neat ethanol-powered vehicles.[91] Automakers agreed to repair poorly converted vehicles and improve engine design to ensure compatibility with ethanol. The government and industry actions restored consumer confidence and the sale of neat ethanol cars increased to over 90% of total car sales between 1983 and 1985.

The third attribute of Phase II was the adoption of pollution control measures by state governments to reduce stillage, a liquid by-product of the sugarcane distillation process. Stillage was initially disposed of in rivers and was the focus of

[91]U.S. General Accounting Office, "Alternative Fuels: Experiences of Brazil, Canada, and New Zealand in Using Alternative Fuels," Report to the Chairman, Environment, Energy, and Natural Resources Subcomittee, Committee on Government Operations, House GAO/RCED-92-119 (Washington, D.C.: U.S. General Accounting Office, 1992), 51-52;

serious environmental concerns. Today, stillage is treated and used as fertilizer for sugarcane fields.

The fourth attribute of Phase II was the implementation of government measures to avoid the substitution of land for food crops to fuel crops, that is land used for sugarcane to be processed into fuel versus land use for food crops. Between 1976 and 1982, land under cultivation increased by 12% to 5.4 million hectares. This increase was divided among sugarcane, 24%; food crops, 35%; and export crops, 41%. The implication is that food crops face greater competition from export crops, particularly soya, than from sugarcane.[92] As of 1992, sugarcane for ethanol production occupied 4.2% of the land area devoted to primary food crops. This low agricultural use is true even in Sao Paulo, where the largest tracts of sugarcane are located and where the highest use of cultivable land (50%) is utilized for agricultural purposes.[93] Crop rotation has increased food production: beans and peanuts are sometimes rotated with sugarcane and the byproducts of ethanol production, such as hydrolyzed bagasse and dry yeast, are used in cattle, chicken, and pork feed.[94]

One criticism of this phase is increased land ownership. The Sugar-Cane Statute enabled sugar mills and ethanol distilleries to control up to 40% of their raw

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[92]Jose Goldemberg *et al.*, *Energy for a Sustainable World* (New York: John Wiley & Sons, 1988), 247-248.

[93]Goldemberg *et al.*, "The Brazilian Fuel Alcohol Program", 855.

material requirements; therefore, land ownership was increased to lower their cost of production.[95] Critics claim that in 1981 some distilleries controlled over 80%, while the national average was about 65%. This increased land ownership caused displacements of food staples, leading to increased seasonality and migration of workers as well as the eviction of small farmers and subsistence peasants who held plots under rentals, partnerships, and illicit forms of land tenure.[96]

During phase two of *Proalcool's* development, ethanol expansion occurred because world oil prices increased and sugar prices decreased. External forces justified the program. Ethanol was seen as a means to energy independence and foreign exchange savings. These objectives were very important to the fiscal integrity and national image of the Brazilian government.

C. *Proalcool's* Phase III (1985 to 1990)

Phase III marked *Proalcool's* maturity. During this period, ethanol shortages and excess consumer demand were experienced. Greater yields in agricultural and industrial productivity occurred. Production was more closely tied to the marketplace and government assistance was significantly reduced. Opponents to the program contested the viability of *Proalcool*, citing declining world oil prices in the

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[94]Ibid.

[95]Bhatia and Pereira, *Socioeconomic Aspects of Renewable Energy Technologies*, 21.

face of an enormous international debt. The government implemented a fuel pricing change, beginning in 1985, which was a disincentive to sugarcane producers and consumers. Shortages of ethanol in 1990 and lower world oil prices shifted consumer purchases to gasoline powered vehicles. The proportion of neat ethanol vehicles sold, out of total vehicles sales, diminished from 95% in 1986, to 69% in January 1989, to only 4.8% in July 1990.[97]

D. *Proalcool's* Phase IV (1991 to present)

Phase IV represents the government's renewed commitment to the ethanol program. The Iraqi invasion of Kuwait in August 1990 raised the problems of continued reliance on oil imports and national energy security. The geopolitical instability of the Middle East provided the impetus for ethanol supporters to argue for an expanded ethanol program. On August 29, 1990, President Fernando Collor announced a complete revision of Brazil's ethanol program, calling for a market of 16 billion liters (339 PJ) of ethanol by the year 2000, and the need of at least 30% sales of ethanol vehicles.[98]

During this period, the environmental benefits of the biomass fuel were highlighted. Substituting ethanol for gasoline significantly contributes to the

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[96]Ibid.

[97]Nastari, "Turbulence Marks Brazil's Alcohol Program," 50.

[98]Ibid., 52.

reduction of carbon dioxide, a major greenhouse gas. Table 7 shows that 9.45 million tons of carbon (MtC) are not released into the atmosphere because of sugarcane production and use, with ethanol accounting for 7.41 MtC and bagasse accounting for 3.24 MtC.

Table 7. Brazil's net $CO_2$ emissions due to sugarcane production and use, 1990-1991, million tons of carbon per year (MtC/year).

| | |
|---|---|
| Ethanol substitution for gasoline | -7.41 |
| Bagasse substitution for fuel oil in other industries | -3.24 |
| Fossil fuel utilization in sugarcane industry | +1.20 |
| Net contribution | -9.45 |

Source: Emilio La Rovere, "Environmental Benefits of the Brazilian Ethanol Programme," in *First Biomass Conference of the Americas: Energy, Environment, Agriculture, and Industry Proceedings Vol. III*, (Golden, CO: NREL, 1993), 1540.

Other environmental benefits of the project include the reduction of airborne lead, which in Sao Paulo decreased ten-fold between 1978 and 1983 due to the substitution of ethanol for leaded gasoline and significantly reduced emissions of carbon monoxide, hydrocarbons, and nitrogen oxides.[99]

In 1995, neat ethanol vehicles represented only 3% of total vehicle sales. Beginning in 1996, the national automotive industry agreed that 20% of total motor

[99]World Bank, *Project Performance Audit Report*, 21.

vehicles would be neat ethanol vehicles.[100] Foreign exchange savings and exports of gasoline and ethanol equal $12.5 and $8.5 billion respectively.

Phases I - IV highlight Brazil's major alternative transportation fuel effort. *Proalcool* came into existence because of the country's increasing oil consumption, increasing trade and budget deficits, and increasing sugar stocks due to depressed worldwide sugar prices. *Proalcool* survived because of external circumstances which precipitated strong governmental support and policies to encourage consumer participation.

SECTION THREE: GOVERNMENT PARTICIPATION AND POLICIES[101]

This section presents the institutions and government policies underlying the ethanol industry. Government participation and support has been integral to *Proalcool's* development. Each administration has affected the ethanol program.

A. Phase I: 1975-1978

President Geisel's decree in November 1975, which created *Proalcool*, also established the National Alcohol Commission as the governmental agency responsible for ethanol production. The major institutional actors were the Sugar and Alcohol Institute (IAA), Copersucar, and Petrobas. The IAA lobbied for the sugarcane

[100] "Brazil Reexamines Ethanol Program as U.S. Group Plans Visit," *Oxyfuel News* (Information Resources Institute: Washington, D.C., Sept. 11, 1995): 5.

[101] This section comes from Daniel Sperling, *New Transportation Fuels*, 76-78; Armand Pereira, *Ethanol, Employment and Development*, 49-59. World Bank,

industry to be the ethanol feedstock and at the same time regulated the sugarcane industry.[102] Copersucar, a cooperative representing the largest ethanol and sugarcane producers in Sao Paulo, lobbied for production subsidies and opposed state-run plantations. Petrobas, the state-owned petroleum monopoly (which was one of the fifty largest corporations in the world at the time[103]), lobbied for control over *Proalcool* to protect its fuel industry and together with the National Petroleum Council determined gasoline production levels and retail fuel prices.

Brazil had advantages in developing its ethanol fueling infrastructure. The principal advantage was that Brazil's government-owned oil company, Petrobas, had considerable control over motor fuel supplies. Petrobas handled more than half of the ethanol distribution through its pipelines and ships, owned 28% of the country's 22,000 fuel stations, and accounted for 25% of all fuel sales.[104]

Easy growth marked the first period because idle excess capacity at the sugar plantations and annexed distilleries was utilized with minimal expenditures and risk.

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*Project Performance Audit Report*, 16-20.

[102]The government established a Comissao de Defesa do Acucar (CDA) in 1931, which regulated sugar production and subsidized producers. CDA was replaced by the IAA, a federal agency, whose board of directors includes sugar cane growers and millers as well as government representatives. IAA also monopolizes sugar exports and collects the revenues from an export tax imposed on sugar in 1956. (IBRD, 1991, 82.)

[103]Sperling, *New Transportation Fuels*, 77.

Producers, especially those at annexed distilleries, received subsidized loans for investments (15 years with 3 years of grace) at negative real interest rates. Until January 1981, those loans covered up to 80% of industrial investments in sugarcane distilleries and up to 90% for those based on other raw materials (i.e., cassava). Nominal interest rates on those loans varied from 2 to 6% plus 40% of the general price index as a partial adjustment for inflation, which prior to 1980 averaged 50% annually.

The government set initial targets of 790 million gallons of ethanol fuel production and consumption by 1980, which was to account for 20% of anticipated gasoline demand. However by late 1978, production targets were met and there was no excess capacity.

Ultimately the difficult access to credit curtailed the ethanol industry's expansion and the National Alcohol Commission was criticized for its ineffective management.

> The program was at a critical juncture: the sugar industry bailout scheme would need to be transformed into an energy scheme in which alcohol fuel pumps would have to be put in place, alcohol vehicles built, and autonomous distilleries become the source of fuel production.[105]

The lack of leadership and political manueverings for control of *Proalcool* significantly weakened the ethanol program.

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[104]U.S. General Accounting Office, *Alternative Fuels*, 31.

B. Phase II: 1979-1984

Phase II began with the oil price increase in 1979 which was the catalyst for President Figueiredo's new administration's announcement of a stronger alternative fuel plan.

The ineffectual National Alcohol Commission was replaced by the National Alcohol Council (CNAL) made up of thirteen members from seven agencies, and given broader authority to implement an expanded initiative.[106] CNAL was given authority to (a) define *Proalcool's* guidelines and criteria for project appraisal; (b) establish incentives and financing conditions, annual production quotas and prices; and (c) authorize exports of molasses and ethanol. This body of high-level executives had very little day-to-day involvement in decision-making concerning resource allocation. CNAL created a five-member Executive Committee (CENAL) to provide technical support to CNAL and to serve as a decision-making body for ethanol distillery projects and encourage ethanol-related research.[107] CENAL's major role was to approve or reject project proposals. An investor interested in a distillery would submit a detailed technical proposal to CENAL and IAA for projects based on sugarcane, or the Secretariat of Industrial Technology (STI) for manioc projects. If

[105]Sperling, *New Transportation Fuels*, 79.

[106]Pereira, *Ethanol, Employment and Development*, 78, footnote 2.

[107]Ibid., 25-26.

the technical proposal was approved, a financial proposal was then submitted to the state-owned commercial Bank of Brazil to receive subsidized credit, and finally the Central Bank of Brazil would review the financial contract. CNAL was under control of the National Monetary Council. The National Monetary Council, which was comprised of representatives from monetary and fiscal authorities, determined how much credit would be available to the ethanol program.

The ministerial-level Council for Economic Development set fuel production targets and producer prices. The IAA determined the prices of sugarcane, molasses and ethanol and specified their use.[108] The ethanol and sugar produced in the country was purchased above cost, and the price was readjusted every six months. The IAA also established quotas for ethanol and/or sugar production in each distillery and/or sugar mill.

In 1979, the government declared a $5 billion target for investment in the ethanol industry between 1979 and 1985. In 1985, an annual ethanol production target of 10.6 billion liters (224 PJ) was announced. Between 1980 and 1982, conditions for loans tightened and distillery operators received loans effectively covering 60% of plant costs (rather than 80% during Phase I).[109]

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[108] Ibid., 26.

[109] World Bank, *Project Performance Audit Report*, 16.

The World Bank states that its loan (originally $250 million) played only a marginally positive role between 1981 and 1985 in lowering subsidies. However, there is no question that interest rate subsidies were lowered between 1981 and 1985.[110]

The government's strong support encouraged automakers to manufacture neat ethanol powered vehicles. Significant state incentives induced consumer purchases and public participation. Neat ethanol cars were cheaper to buy because of lower vehicle registration fees, lower fuel prices, and easier access to credit.

C. Phase III: 1985-1990

During Phase III, Jose Sarney's government policies changed to the detriment of both ethanol producers and consumers. Ethanol shortages jeopardized the alternative fuel program and undermined producer support and consumer confidence.

By mid-1985, the interest rates on *Proalcool* loans, excluding those to the Northeast and North regions, had increased to 5% plus 100% of the general price index. The number of projects approved decreased dramatically because of declining world oil prices.

In 1984, the government changed the fuel pricing policy which resulted in insufficient sugarcane production and the necessity to import ethanol and methanol. The government established an index for prices paid to sugarcane producers using

[110]Ibid., 17.

1978 as the base year. So in 1984, producers received 77% of the price they had been paid, and by 1990, they received 42% of what they made in 1978. Many independent cane growers could not afford to grow sugarcane. The independent cane growers' share of the total amount of cane crushed dropped from 48% in the 1985/86 crop year to less than 20% in the 1990/91 crop year. Sugar mill and distillery owners planted more cane, but were only able to stabilize the supply of cane at the level of 220 million tons/year and 3.06 billion gallons of anhydrous ethanol. Demand for ethanol increased in part due to the success of the neat-ethanol vehicle to almost 11.8 billion liters (250 PJ), the equivalent of 168,378 barrels/day of gasoline.[111] The insufficient fuel supply required the government to increase fuel ethanol prices for consumers. The ratio of prices of hydrous ethanol (for neat-ethanol vehicles) to gasoline rose from 0.65 to 0.75.

Ethanol imports met part of the ethanol shortage, but not totally. European wine ethanol and US corn ethanol imports did not close the gap between the supply and demand for ethanol. Therefore, a methanol blend (60% hydrous ethanol, 33% methanol, and 7% gasoline) was utilized. It had the same properties of hydrous ethanol and was tested by the Brazilian automobile industry. The mixture was approved by the local environmental organizations, but was not accepted by the public. Subsequently, ethanol shortages were inevitable in most Brazilian cities

[111]Nastari, "Turbulence Marks Brazil's Alcohol Program," 49.

between March and May of 1990. The only place where ethanol, pure or in blends with methanol, was regularly available was the city of Sao Paulo.[112]

The number of neat ethanol vehicles produced peaked and ebbed during this period. The proportion of neat ethanol vehicles sold to total vehicle sales diminished from 95% in 1986, to 69% in January 1989, to only 4% in August 1990. The year-end figure for ethanol vehicle sales in 1990 was 11.6%.

The outlook for the alternative fuel program was bleak in 1990. If Iraq had not invaded Kuwait in August 1990, the program's future would have been in jeopardy.

D. Phase IV: 1991 to Present

Phase IV is the latest phase denoting a change in the government's role in the ethanol industry. Cenal and the IAA were dissolved as two separate entities in 1991. The combined employees of 2100 were reduced to an office of 18 people. In August 1990, President Collor nominated a task force to study reducing the government's involvement in the sugar and ethanol industries. Sugar and ethanol producers sought three major concessions: increased prices paid to ethanol producers, increased credit to expand sugarcane acreage, and producer debt renegotiation. In February 1991, the government began negotiations on debt restructuring for the ethanol and sugar producers and in addition, also promised $100 million in credit for planting. Also,

[112]Ibid.,48-49.

prices paid to ethanol producers were raised to the rate of inflation starting in January 1991. These were important concerns of sugar and ethanol producers and demonstrated the government's recommitment to the ethanol industry. A 16 billion liter (339 PJ) ethanol program was targeted.

While the level of government support has varied, it must be noted that *Proalcool* is a private endeavor, with government policies continuing to underpin the ethanol industry.

SECTION FOUR: PRIVATE SECTOR PARTICIPATION

The ethanol industry affects many sectors in the economy because of the backward and forward linkages involving agriculture and manufacturing. This section presents data on ethanol production, ethanol consumption, industrial and agricultural investment as well as automobile production.

A. Ethanol Production

Ethanol production increased from 555.6 million liters (11.8 PJ) in 1976 to 12.7 billion liters (269 PJ) in 1996. Ethanol yields in 1977 were 2,663 liters per hectare, growing to 3,811 liters per hectare in 1985, an average annual increase of 4.3%. During the same period, agriculture yields increased 16% (measured in tons of cane per hectare) and industrial yields increased 23% (liters of ethanol per ton of cane). By 1989, the average yield in the state of Sao Paulo was 4,700 liters of ethanol per hectare.[113]

Figure 9 shows the actual amount of ethanol produced from the program's beginning. The most dramatic expansion in ethanol output occurred during Phase II. Between 1979 and 1985, 368 new projects were approved to replace gasoline with ethanol blends (anhydrous alcohol) and hydrous alcohol was introduced as a neat fuel for automobiles. In 1985 and 1986, approval for new projects was reduced drastically as existing supply met consumption demand. Continued government support for any ethanol expansion was strongly opposed by petroleum interests, especially since oil was discovered off the Brazilian coast and the world price for crude oil was $16 per barrel in 1986. The government provided subsidies for new distilleries through 1986 to meet the consumption needs of the ethanol demand. Ethanol production leveled off in 1987 with constant annual production between 10.5 billion liters (223 PJ) and 11.5 billion liters (243 PJ). In 1987, entrepreneurs themselves financed the additional 101 plants. Current *Proalcool* production capacity is 16 billion liters (339 PJ).

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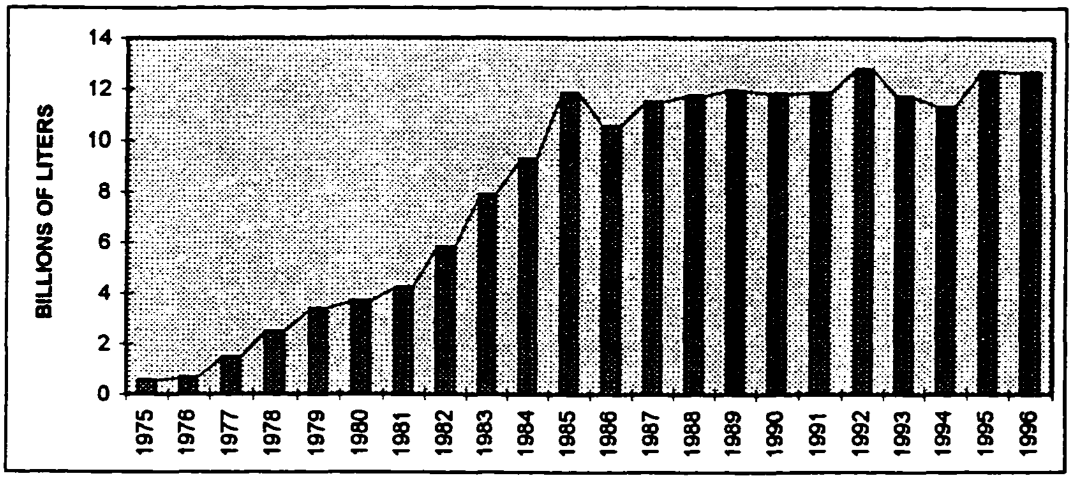
[113]Goldemberg *et al.*, "The Brazilian Fuel Alcohol Program," 848.

FIGURE 9. ANNUAL ETHANOL PRODUCTION, 1975 TO 1996.




Source: 1975-1988: CENAL, *The National Alcohol Program*, (Brasilia, Brazil: CENAL,1988); 10; 1989-1996: Datagro, "Brazilian Ethanol Production 1987-1996," (Sao Paulo, Brasil: Datagro, 1996).

B. Ethanol Consumption

Significant government incentives were provided to stimulate consumer interest in fuel ethanol. Initially, the price of ethanol was capped at 65% of gasoline's price because it contained two-thirds the energy content of gasoline. The price of ethanol has always been lower than gasoline, fluctuating between its lowest price of 52% and 75% of gasoline's price. During the first phases, ethanol was more accessible because the government prohibited the sale of gasoline on weekends and only permitted the sale of ethanol.

Ethanol is both a replacement for imported gasoline and an export commodity. The cumulative foreign exchange savings and export earnings due to ethanol production have been significant. The use of ethanol saved $12.5 billion in foreign exchange between 1976 and 1987. During the same period, the value of gasoline and ethanol exports was $8.5 billion. Over $21 billion is credited to the ethanol industry as the equivalent cost of imported gasoline and the value of Brazilian exports of ethanol and gasoline.

C. Industrial and Agricultural Investment in *Proalcool*

The total investment in ethanol distilleries between 1975 and 1989 reached $7 billion, of which $4 billion was from the government and $3 billion was from entrepreneur's resources. Investment in agriculture and industry was $2.2 billion and $4.8 billion respectively. In 1981, investment increased significantly due to expanded production goals announced in 1979 and broader development objectives articulated by the government. Investment declined substantially between 1988 and 1990 because of ethanol shortages, reduced ethanol-fueled car production, oil discoveries off the Brazilian coast, and government fiscal problems. However, when Iraq invaded Kuwait in 1990 the government support of the ethanol industry was renewed.

D. Ethanol Powered Automobile Production[114]

Automobile manufacturers began producing neat ethanol vehicles in late 1979, after initial ethanol production targets were met. Government incentives

[114]This section comes from U.S. General Accounting Office, *Alternative Fuels*,

encouraged the purchase of neat ethanol vehicles. These vehicles were cheaper than conventional gasoline vehicles due to lower registration fees, easier credit terms, reduced down payments, and longer repayment schedules.

Neat ethanol vehicles were introduced in late 1979, and by the end of 1980, they captured 73% of the market. However, the first vehicles had problems starting in cold weather and parts deteriorated due to the corrosion of fuel and exhaust system parts. These fuel-related problems and concurrent ethanol price increases resulted in new neat ethanol vehicle sales falling to less than 10% of total vehicle sales by July 1981. Figure 10 shows the production of ethanol-powered motor vehicles. To restore public confidence, a major auto maker agreed to ensure that all ethanol vehicle warranty claims were fully satisfied; to improve ethanol engines and materials compatibility; and to upgrade ethanol vehicle warranties to match or exceed those for gasoline vehicles. Consumer support increased steadily and by 1985, the new improved vehicles accounted for 95% of all new vehicle sales. From late 1989 to early 1990, there was an acute shortage of ethanol, which resulted in a major drop in ethanol vehicle sales by mid 1990. By October 1991, the share of neat ethanol-powered vehicles grew to about 26% of total vehicle sales, or 4.2 million neat ethanol vehicles and 5 million ethanol/gasoline mix powered vehicles.[115]

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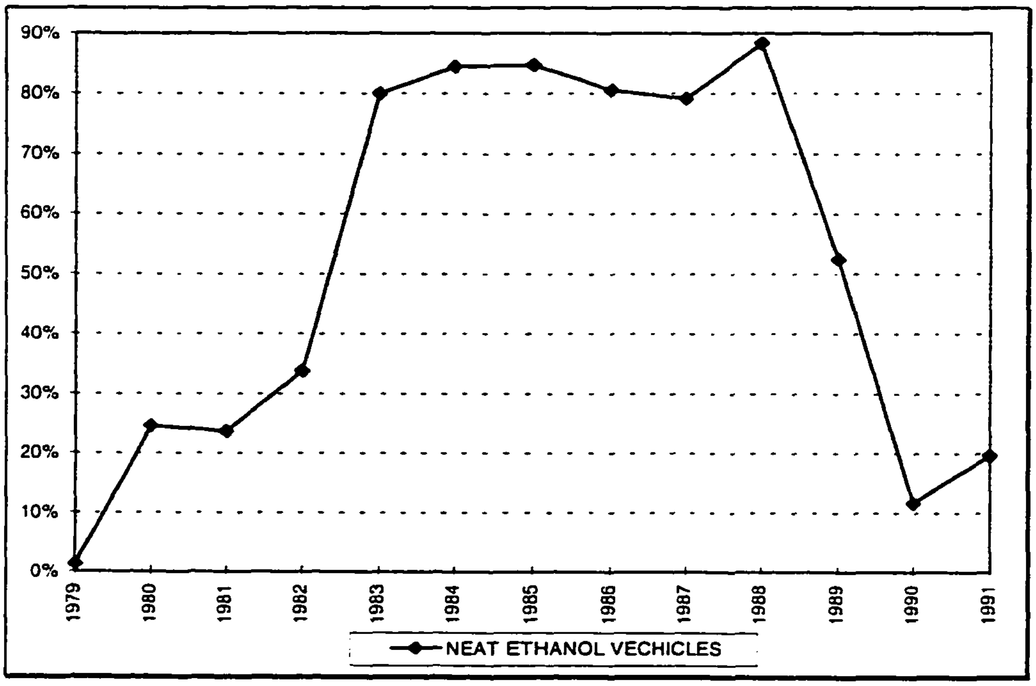
33.

[115]Goldemberg *et al.*, "The Brazilian Fuel Alcohol Program," 843.

FIGURE 10. PERCENTAGE OF NEAT ETHANOL VEHICLE SALES, 1979-1991.




Source: 1979-1988: CENAL, *The National Alcohol Program*, (Brasilia, Brazil: CENAL,1988); 10; 1989-1991: Plinio Nastari, personal correspondence, 1992.

Government and industry intervention was critical to the development of ethanol powered motor vehicles. Consumers responded to government incentives and assurances by automobile manufacturers.

SECTION FIVE: BRAZILIAN HOUSEHOLD ENERGY CONSUMPTION

Residential energy use accounts for 29% of total commercial energy demand. In 1985, there were approximately 30 million households of which an estimated 76% lived in urban areas.[116]

[116]G. De Martino Jannuzzi, "Residential Energy Demand in Brazil by Income Class," *Energy Policy* (June 1989): 259.

Table 8 shows the percentage of households that used gasoline, liquid propane gas (LPG) and city gas, electricity, fuelwood, charcoal, and kerosene between 1960 and 1985. Household gasoline consumption increased from 4% in 1960 to 25% in 1985. Residential electricity use doubled between 1960 and 1985, increasing from 38% to 80%. During the same period, LPG and city gas consumption rates increased four fold from 18% to 78%. The use of fuelwood decreased by half; kerosene consumption declined from 20% to 7%; and use of charcoal remained constant at 4%.

Table 8. The penetration levels of fuels and electricity in Brazil's residential sector between 1960-85, percentage.

| Fuel | 1960 | 1970 | 1980 | 1985 |
|---|---|---|---|---|
| Gasoline | 4 | 9 | 22 | 25 |
| LPG and City Gas | 18 | 43 | 63 | 78 |
| Electricity | 38 | 47 | 68 | 80 |
| Fuelwood | 61 | 45 | 31 | 28 |
| Charcoal | 5 | 4 | 6 | 4 |
| Kerosene | 20 | 20 | 14 | 7 |
| Total number of households (millions) | 13 | 18 | 25 | 30 |
| Urban | 47 | 58 | 70 | 76 |

"Reprinted from *Energy Policy*, Gilberto De Martino Jannuzzi, Residential energy demand in Brazil by income classes, 254-263, © (June 1989), with permission from Elsevier Science."

It is noteworthy that residential electricity has become more widely available; in 1985 it was consumed in eight out of ten households. It is also interesting that gasoline was consumed by only one in four households in 1985. These findings suggest that distributive characteristics may explain why gasoline had the least penetration of the modern fuels, i.e., only the wealthy could afford to purchase cars and gasoline.

Table 9 indicates household energy consumption by income levels. It shows that the demand for modern fuels comes from households with monthly incomes greater than 5 minimum wages (MW) representing 30% of the country's total number of households. Lower income households, those with less than 5 MW, predominantly consume LPG and city gas, electricity, and fuelwood. Gasoline demand is concentrated in the two upper-income classes: 72% of households with 10-20 MW consume gasoline, this percentage increases to 90% of households with more than 20 MW. In addition, urban households consume about 3 times more gasoline energy than the rural household, on average.

There is a direct relationship between income and modern fuel use. As household income increases, household consumption of gasoline, LPG and city gas, and electricity increases. The biggest difference in energy consumption between the upper and lower income classes is that the rich consume significantly more gasoline and the poor consume significantly more fuelwood.

Table 9. The penetration levels of modern fuels in the residential sector of Brazil by income class in 1979, percentage.

| Fuel | Income | Level | | | | Average | | |
|---|---|---|---|---|---|---|---|---|
| Minimum Wage | <2 | 2-5 | 5-10 | 10-20 | >20 | Total | Urban | Rural |
| Gasoline | 3 | 16 | 44 | 72 | 90 | 24 | 29 | 11 |
| LPG & Gas | 39 | 79 | 92 | 98 | 98 | 67 | 84 | 27 |
| Electricity | 58 | 79 | 94 | 98 | 99 | 71 | 90 | 24 |
| Fuelwood | 74 | 44 | 22 | 12 | 6 | 31 | 11 | 77 |
| Households by income class as % of total | 37 | 33 | 17 | 9 | 4 | | | |

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Table 10 shows the unevenness of household energy consumption by income class. Households with more than 20 MW consume 6 times more electricity than households with less than 2 MW; LPG and city gas consumption is 2 times greater for the richest compared to the poorest. Households with more than 20 MW consume about 115 GJ/year of gasoline, or 3 times more energy than the lowest-income household. This is due partially to the higher intensity of vehicle use and to the ownership of more than one car per household.

Household consumption of modern fuels increases with income. Electricity, LPG and city gas have already reached residential penetration levels of 80% and

78% respectively. Therefore, as incomes increase it will take less time for households to reach their maximum level of use. Gasoline on the other hand has a residential penetration of only 25%. As incomes increase motor vehicle use will also increase - driving the demand for gasoline up. It will take longer to meet the demand for increasing gasoline. Ethanol has the potential to meet residential energy demand for gasoline.

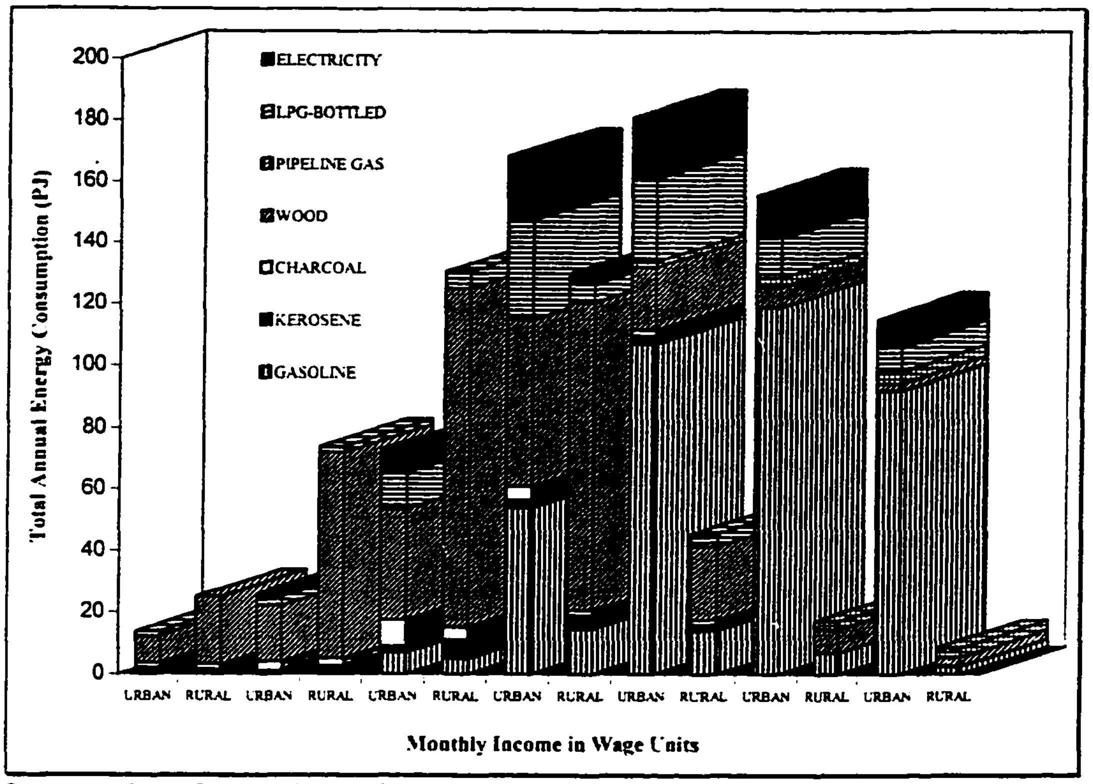
Table 10. Average consumption levels per household of gasoline, liquid propane gas, and electricity by income class in 1979, GJ/year.

| | Income Level | | | | | Average | | |
|---|---|---|---|---|---|---|---|---|
| Minimum Wage | <2 | 2-5 | 5-10 | 10-20 | >20 | Total | Urban | Rural |
| Gasoline | 39 | 52 | 68 | 85 | 115 | 75 | | |
| LPG | 6 | 7 | 8 | 9 | 11 | 7 | 8 | 6 |
| Electricity | 2 | 4 | 6 | 8 | 12 | 5 | 5 | 2 |

"Reprinted from *Energy Policy*, Gilberto De Martino Jannuzzi, Residential energy demand in Brazil by income classes, 254-263, © (June 1989), with permission from Elsevier Science."

Figure 11 shows a direct relationship between income and modern fuels, especially gasoline. Gasoline use, particularly in urban areas, increases dramatically with increased income. The market development for a substitution for gasoline seems to have much potential in urban centers.

FIGURE 11. HOUSEHOLD ENERGY CONSUMPTION.




Source: Jose Goldemberg, *Energy for a Sustainable World*, © (New York: John Wiley & Sons,1988), 220. Reprinted with permission of John Wiley & Sons, Inc.

SECTION SIX: CONCLUSION

In 1975, the Brazilian government established *Proalcool*, an ambitious program to substitute ethanol for gasoline because instability in the world oil and sugar commodity markets was driving the country bankrupt. Brazil's oil imports grew from 20% in the 1950s to 80% in the 1970s with oil imports costing $3.2 billion or 39.5% of exports. Energy self-sufficiency and foreign exchange savings were the primary goals of the program.

Four phases mark *Proalcool's* development. The first phase (1975 to 1978) was characterized by government supported expansion of anhydrous ethanol production (mixing gasoline with 20% by volume of ethanol) at annexed distilleries which are attached to sugar plantations. Phase two (1979 to 1984) was the ethanol industry's boom phase. The government provided industry incentives for the development of the autonomous distilleries which are located independently of sugar plantations to produce hydrous (neat or pure) ethanol as well as consumer incentives to purchase neat ethanol-powered vehicles. Phase three (1985 to1989) was known as the maturity stage and is marked by declining government support, ethanol shortages, lower world oil prices, and drastically reduced sales of neat ethanol-powered vehicles. Phase four (1990 to present) represents the government's renewed commitment to the ethanol industry. The environmental benefits of ethanol use was recognized.

Ethanol production levels increased from 555 million liters in 1975 to almost 13 billion liters in 1995. Between 1975 and 1989, investment in the ethanol industry totaled $7 billion; with $3 billion coming from industry and $4 billion coming from government. Ethanol currently accounts for 27% of all motor fuels sales with over 4.5 million neat ethanol-powered vehicles. Most recently neat-ethanol powered vehicles represent 20% of total vehicles sales. The use of ethanol as a blend with conventional gasoline and as a neat alternative fuel saved millions of dollars in foregone oil imports and generated revenue due to the export of ethanol and gasoline.

In 1985, there were approximately 30 million households, of which an estimated 76% lived in urban areas. A direct relationship between transportation fuel consumption and household income exists. While residential electricity was consumed in eight out of ten households, gasoline was consumed by only one in four households. Gasoline demand is concentrated in the two upper income classes which represent about 13% of all households. Urban households consume about 3 times more gasoline than rural households. The implications of Brazil's household energy consumption suggest that as more people live in urban areas and as their incomes increase, it is expected that more people will be purchasing motor vehicles and driving them.

This chapter showed the development of the ethanol industry and its linkages to industry, government, and households. The ethanol industry plays a significant role within Brazil's economy. The next chapter examines the employment and distributional implications of two different technologies used in ethanol production.

## CHAPTER FOUR

## ETHANOL'S EMPLOYMENT AND DISTRIBUTIONAL IMPLICATIONS

Increased employment and reduced regional income inequality were two major objectives of the *Proalcool* program. This chapter discusses the employment and distribution effects of two ethanol production technologies. The ethanol distilleries located in the rural northeast are classified as the traditional technology because of the greater labor requirements due to less harvest mechanization. The ethanol distilleries located in the urban center-south are considered the modern technology because they have the country's most developed sugar production and ethanol distillation technology. Section one presents the employment estimated with the ethanol technologies. Section two discusses the distributional effects of the ethanol production technologies.

### SECTION ONE: EMPLOYMENT[117]

The alternative fuel program generates significant job creation within the energy sector. Table 11 shows that the ethanol industry employs the greatest number

[117]This section comes from Geller, "Ethanol Fuel From Sugar Cane in Brazil," 146-149; and Pereira, *Ethanol, Employment and Development*, 105-123.

of workers of the following four energy sub-sectors: ethanol, oil, electricity, and coal.

Table 11 Employment in the energy sector.

| Sector | Jobs | Energy Production (BOE/Day) | Jobs/BOE |
|---|---|---|---|
| Ethanol | 707,289 | 103,200 | 6,854 |
| Oil | 55,000 | 1,206,000 | 0.045 |
| Electricity | 180,500 | 1,198,000 | 0.15 |
| Coal | 12,500 | 65,000 | 0.192 |

Source: Plinio Nastari, "Recent developments in Brazil's National Alcohol Program," Third Annual Ethanol Conference. Lincoln, NE (September 1990).

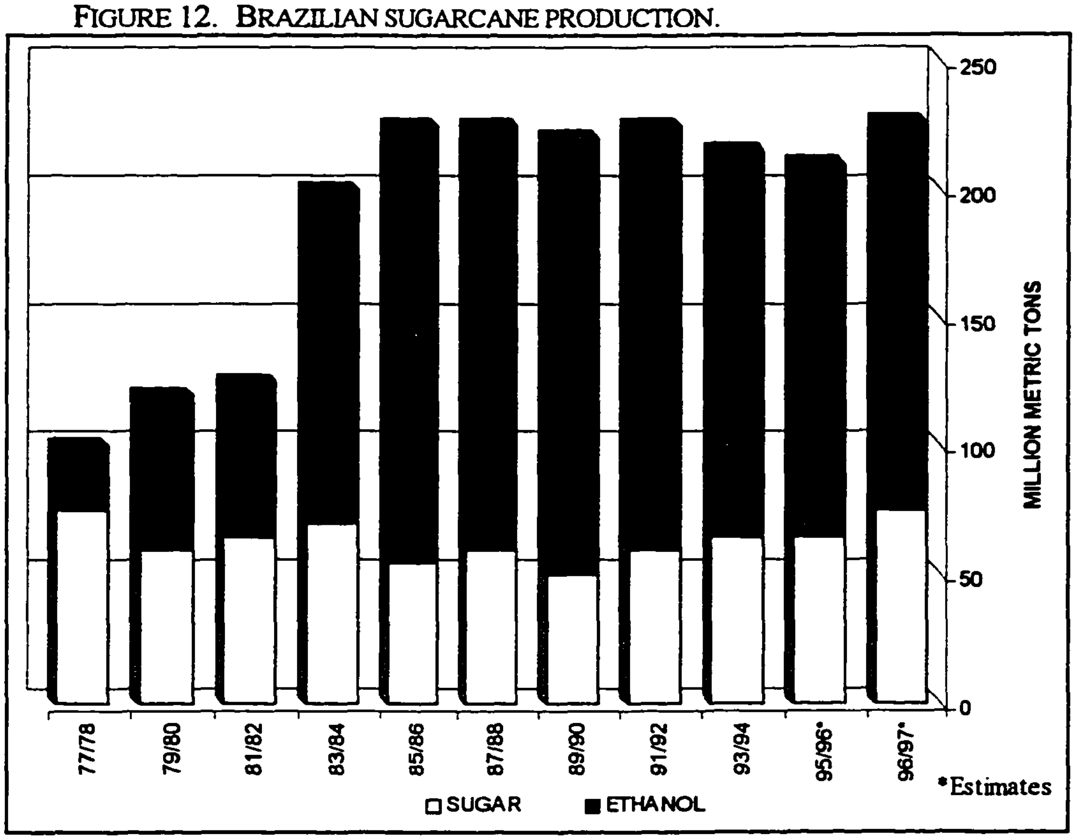
Ethanol production is highly labor intensive because of its backward and forward agro-industrial linkages. However, several factors complicate determining the ethanol industry's direct and indirect employment. Demand for labor in producing ethanol is uneven because of differences in labor and land productivity, between and within regions; the technologies utilized; as well as the large number of seasonal and unsalaried workers.

Two kinds of employment are associated with ethanol production. First is the agricultural employment involved in the production of ethanol's feedstock, sugarcane. Agricultural labor is used mainly for sugarcane production and represents the majority of the labor required for ethanol production. Second is the industrial employment involved with the distillation of ethanol. Industrial labor is highly seasonal, since distilleries typically operate between 150 and 180 days per year.

A. Sugarcane Production

Brazil is the world's largest sugarcane producer and the second largest producer of raw sugar. Figure 12 illustrates the levels of sugarcane production between 1975 and 1995. Brazil has tripled sugarcane production from almost 70 million metric tons in 1975 to estimates of 226 million metric tons in 1996/97. About 66% of the sugarcane produced converted into ethanol and 34% into sugar.[118]

FIGURE 12. BRAZILIAN SUGARCANE PRODUCTION.




Source: Stephen Vuilleumier, "Global Nutritive Sweetner Outlook," mimio. 1996, 3.

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[118]Stephan Vuilleumier, "Global Nutritive Sweetner Outlook," paper presented to 19th Annual Seminar on Purchasing, (Kansas City, MO: June 3, 1996) 1-3.

Sugarcane is the basis for sugar, anhydrous ethanol, and neat ethanol (hydrous ethanol) production. Table 12 provides annual production levels of cane, sugar, and ethanol between 1975 and 1995. Table 13 shows that there has been a dramatic change in the percentage of sugarcane used to make sugar, anhydrous ethanol, and hydrous ethanol between 1975 and 1995. The production of hydrous ethanol increased the most from 8% in 1975 to 50% in 1995. Whereas sugar production decreased from 86% in 1975 to 35%. Anhydrous ethanol blends increased from 6% in 1975, to a high of 33% in 1983, and decreased to 15% in 1995. Sugarcane production has shifted from sugar to ethanol production.

Table 12 Annual production of cane, sugar, and alcohol between 1975 and 1995.

| Production | 74/75 | 76/77 | 78/79 | 80/81 | 82/83 | 84/85 | 86/87 | 88/89 | 90/91 | 92/93 | 94/95 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cane ($10^6$ tons) | 68.322 | 87.826 | 107.626 | 123.008 | 166.178 | 201.218 | 225.539 | 220.104 | 222.429 | 223.459 | 240.944 |
| Sugar ($10^6$ tons) | 5.887 | 7.208 | 7.342 | 8.100 | 8.857 | 8.848 | 8.151 | 8.070 | 7.365 | 9.261 | 11.726 |
| Anhydrous alcohol ($10^9$ liters) | 0.232 | 0.300 | 2.095 | 2.104 | 3.549 | 2.102 | 2.163 | 1.718 | 1.288 | 2.216 | 2.869 |
| Hydrous alcohol ($10^9$ liters) | 0.323 | 0.363 | 0.395 | 1.602 | 2.273 | 7.089 | 8.343 | 9.928 | 10.228 | 9.480 | 9.827 |

Source: Luiz Carvalho, "The prospects for ethanol production in Brazil," *International Sugar Journal* 98, no. 1170 (1996): 289.

Table 13 Sugarcane production expressed in same unit of measurement

| | 74/75 | 76/77 | 78/79 | 80/81 | 82/83 | 84/85 | 86/87 | 88/89 | 90/91 | 92/93 | 94/95 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sugar | 85.93 | 86.20 | 62.53 | 55.58 | 46.50 | 35.86 | 31.08 | 28.77 | 27.19 | 31.54 | 34.92 |
| Anhydrous | 6.04 | 6.39 | 31.73 | 25.67 | 33.14 | 15.15 | 14.67 | 10.88 | 8.44 | 13.42 | 15.19 |
| Hydrous | 8.04 | 7.42 | 5.74 | 18.75 | 20.35 | 48.99 | 54.25 | 60.35 | 64.37 | 55.04 | 49.89 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Source: Luiz Carvalho, "The prospects for ethanol production in Brazil," *International Sugar Journal* 98, no. 1170 (1996): 289.

Sugarcane is produced in two regions. The Center-South (C/S) area includes the states of Sao Paulo and Rio de Janeiro; the Northeast (N/E) area includes the states of Pernambuco and Alagoas.[119] Year-round sugarcane production occurs because of complementary crop seasons: the season in the C/S is between May and November, while the season in the N/E region is between September and April. There are also significant differences in climate, soil, and technology between the regions.

The factors which most influence sugarcane yields are: amount of sunlight (sunlight influences the photosynthesis of sugarcane, which in turn affects tonnage per hectare, and the sugar content in each ton of cane), soil quality, rainfall during the post-harvest season (the greater the better), rainfall during the harvest season (the lower the better), temperature during the harvest season (the lower the better as colder temperatures enhance sugarcane maturation), and application of herbicides and fertilizers (when prices paid to cane producers, which is determined by the government, falls, there is a noticeable reduction in the application of inputs, i.e., herbicides and fertilizers).[120]

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[119]World Bank, *Trade, Exchange Rate, and Agricultural Pricing Policies* (Washington, D.C.: The World Bank, 1991), 44.

[120]Private Correspondence with Dr. Plinio Nastari, 1990.

B. Sugarcane Production and Employment

Employment in the agricultural and agro-industrial sectors is largely determined by the production cycle of sugarcane and crop renewal techniques utilized by plantations and farmers. First, there are two varieties of sugarcane: one which takes 12 months before harvesting and the other which has an 18 month maturation period. The 18 month type is the most common.

The replanting and cultivation of sugarcane is not consistent among producers and this has implications for employment and sugarcane yields. The most efficient and optimal crop renewal technique is not always chosen. One reason is the varying levels of demand for sugarcane. An unstable annual demand for sugarcane may motivate a farmer to plant all the sugarcane in one year to maximize the yield in the first harvest. However, the farmer will have diminishing returns thereafter, and not be able to replant in the second and third years to compensate for the increasing losses. Non-optimal crop renewal practices result in alternating surpluses and deficits of sugarcane, as well as off-season periods without any planting.

The most optimal planting pattern for a distillery's plantation is to stagger the planting periods. The first planting yields the necessary amount to meet the demand in the first harvest season, while the second and third plantings provide the additional yields to compensate for the diminishing crop returns of the first planting. This crop planting ensures a stable supply of sugarcane and annual planting (although decreasing from the first planting to the third and increasing again thereafter). Furthermore, part of the land area may be used for the production of other crops under alternative integrated farming techniques, which would ensure additional returns per hectare and more stable employment.

Employment in the sugarcane sector is a function of the planting patterns and crop renewal techniques. Cultivation and maintenance activities create a year-round demand for labor, but employment is much higher and more stable in plantations where the planting activities are evenly distributed.

## C. Ethanol Production

Two different types of distilleries are used in the production of ethanol, annexed and autonomous. The annexed distillery is usually attached to a sugar mill. It has much flexibility in switching production between sugar and ethanol because sugar juice from the sugarcane crusher can be milled into sugar or distilled into ethanol. Historically, annexed distilleries have generated supplemental income by producing ethanol. When sugar prices are low, more sugarcane juice is diverted to the annexed distillery for fermentation into ethanol. When sugar prices are high more sugar juice is milled into sugar. World sugar and ethanol prices influence production levels of both. Until the beginning of the *Proalcool* program in 1975, the only ethanol production technique was the distillation of molasses (a by-product) from the sugar milling process.[121]

Autonomous distilleries are different from annexed distilleries. Autonomous distilleries are independent, stand-alone plants that produce ethanol exclusively. They are located near new sugarcane plantations and receive sugarcane from small producer cooperatives. The development and expansion of autonomous distilleries began in 1979 in order to contribute to rural development and to decentralize the production and supply of ethanol.[122]

D. Ethanol Production Process

Ethanol is produced directly through the fermentation of sugarcane juice (called "direct" ethanol), and through the fermentation of molasses obtained from sugar production ("indirect" ethanol). Figure 13 shows that the production of ethanol from sugarcane involves three major stages: pretreatment (sucrose extraction), bioconversion fermentation), and product recovery (distillation).

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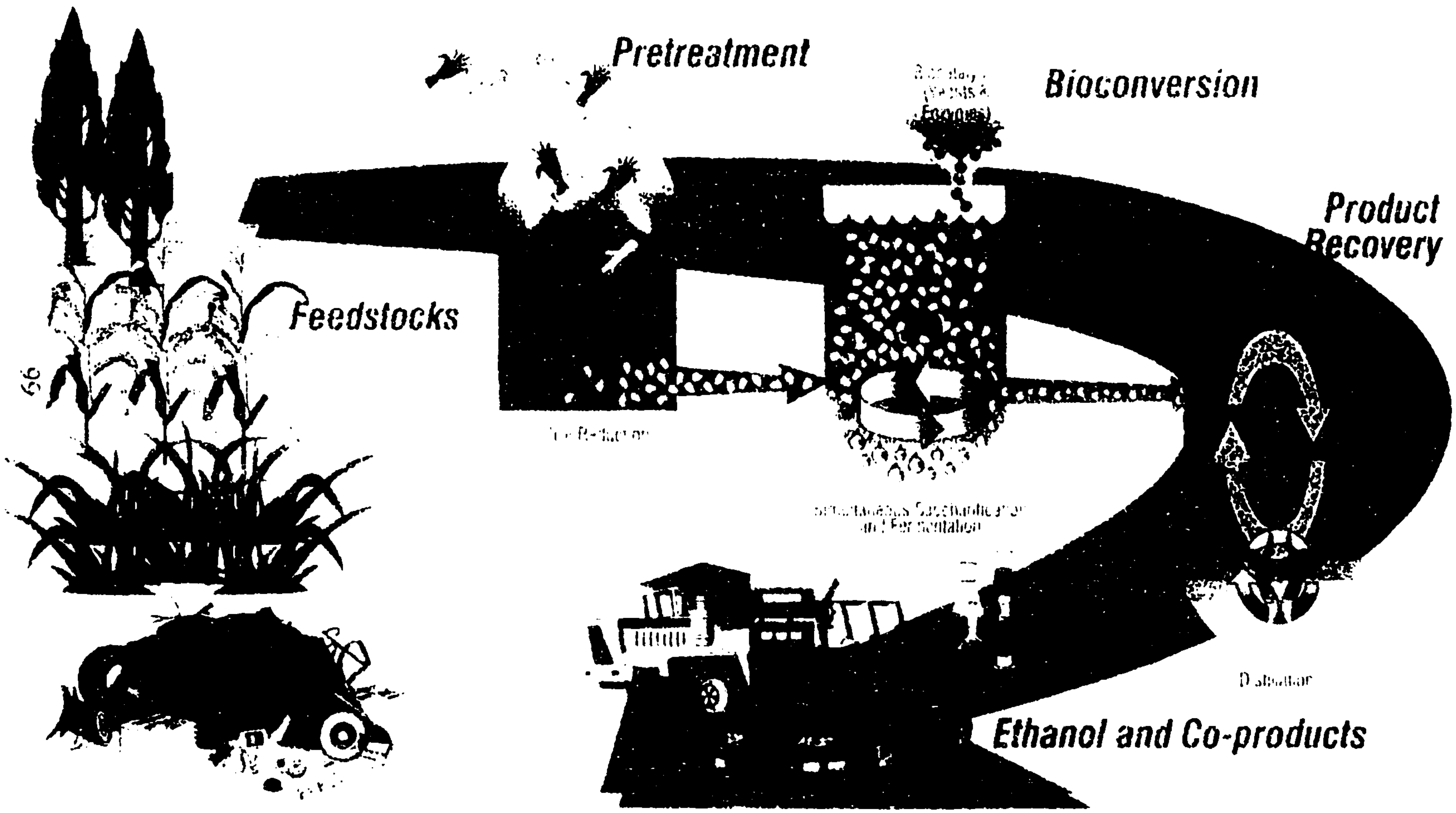
[121]Kevin Rask, "The Social Costs of Ethanol Production in Brazil: 1978-1987," *Economic Development and Cultural Change* (1995): 629.

[122]Ibid.

FIGURE 13 ETHANOL PRODUCTION PROCESS




Source. National Renewable Energy Laboratory, "Biofuels for Transportation: The Road from Research to the Marketplace," (Golden, CO, National Renewable Energy Laboratory, January, 1995) 3-4, (CD-STI-G1013301)

The technology to convert sugarcane to ethanol is simple.[123] An ordinary distillery's electricity and steam production can be generated utilizing sugarcane bagasse. Bagasse, the sugarcane residue from the milling process, is a fibrous material which is used in the industrial process because it can be immediately burned to produce steam.

Step One: Sucrose Extraction

After sugarcane is harvested, it is immediately transported to distilleries. The most common distilleries produce 120,000 liters of ethanol per day while the largest produce one million liters of ethanol per day. Upon arrival, the sugarcane is washed to remove stones and soil dust; then, chopped and crushed in milling machines. The sugarcane is milled using at least two sets of three stainless steel cylinders; the fiber is dampened again in water and then goes through another milling operation. The extracted product, known as beer, is then diluted in water up to one part of sugar to six parts of water.

[123]This section comes from J.R. Moreira and J. Goldemberg, "Alcohols - Its use, energy and economics - A Brazilian Outlook" *Resource Management and Optimization* 1, no. 3 (January 1981): 231-279. See pages 235-238 for further details.

Step Two: Fermentation

The beer is refrigerated in large stainless steel containers, cooling to avoid temperatures from going above 30-35° C during the time required for efficient fermentation. (Generally twelve hours for economical reasons; a longer time span produces more ethanol, but since the efficiency of the yeast decreases significantly when a 7 or 8% per volume of alcohol is achieved, it then requires up to 36 hours to obtain alcohol in concentrations of 9 to 10%.)

Step Three: Distillation

The alcohol-water mixture undergoes distillation. The residual water is then removed using a mixture which contains benzene. The alcohol is submitted to a new distillation (retification) where the benzene is recovered and water free alcohol is obtained.

Step Four: Storage

The ethanol is then stored. Since ethanol distilleries work only 160-180 days per year, the build-up of large stocks to supply the market all year around is required.

E. Ethanol Production and Direct Employment

Employment in the ethanol sector depends on two regions of sugarcane and ethanol production. These regions have distinct agricultural and industrial differences. The distilleries of the N/E are classified as the traditional technology in part because they are located in a relatively mountainous area with a greater supply of agricultural workers than the C/S area. These distilleries have higher production costs due to increased transportation costs, less harvest mechanization, and extra infrastructure needed for production. The labor input requirements of the N/E are two to eight times higher than those of the C/S region. Ethanol distilleries of the C/S are classified as the modern technology because they are located in the more urban area. These distilleries have the most developed sugar production, sugarcane harvest mechanization, distillation technology, investment in research and development, and modern plants. This area has a shortage of agricultural workers.[124]

Several studies estimate the direct agricultural and industrial employment associated with the production of ethanol. Jose Goldemberg *et al.* estimate that *Proalcool* generates 475,000 direct jobs and 700,000 at the peak of the harvest season, noting that the N/E region has much less agricultural mechanization and is more than three times as labor intensive as the C/S region.[125]

Armand Pereira estimates that the ethanol industry generates 501,253 jobs. He collected information on six occupational groups involved in producing ethanol.

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[124]Rask, "The Social Costs of Ethanol Production in Brazil: 1978-1987," 629-630.

[125]Goldemberg *et al.*, "The Brazilian Fuel Alcohol Program," 854; Goldemberg *et*

He finds that direct employment includes: 68,345 administrative/agro-industrial jobs during the harvest season and 48,728 jobs during the off-season. In addition, direct employment in the agricultural sector numbers 236,419 during the harvest season and 147,761 during the off-season.[126]

Geller estimates total direct employment associated with the production goal of 10 billion liters to be about 620,000 workers; the equivalent of about 420,000 full-time jobs.[127] Table 14 shows the direct employment created by a typical 120,000 liters/day distillery in the C/S and N/E regions. Agricultural labor is used mainly for planting and harvesting sugarcane and represents 75-90% of the total labor required for ethanol production. Nearly three times as much labor is needed during the six month harvesting season as in the six month land preparation and planting season. Consequently, there are about twice as many temporary jobs as permanent jobs in sugarcane production. Likewise, industrial labor is highly seasonal, since distilleries typically operate between 150 and 180 days per year.

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*al.*, *Energy for a Sustainable World*, 252.

[126]Pereira, *Ethanol, Employment and Development*, 58.

[127]Geller, "Ethanol Fuel From Sugar Cane in Brazil," 146-149.

Table 14: Brazilian employment in ethanol industry by region.

| | Total jobs | Total jobs | Total labor (person-yrs) | Total labor (person-yrs) |
|---|---|---|---|---|
| | Center-South Modern | Northeast Traditional | Center-South Modern | Northeast Traditional |
| Agriculture | | | | |
| Permanent | 230 | 890 | 230 | 890 |
| Temporary | 450 | 1770 | 225 | 885 |
| Subtotal | 680 | 2660 | 455 | 1775 |
| Industrial | | | | |
| Permanent | 85 | 85 | 85 | 85 |
| Temporary | 125 | 125 | 65 | 65 |
| Subtotal | 215 | 215 | 150 | 150 |
| TOTAL | 895 | 2875 | 605 | 1925 |

Based on a 120,000 liters per day distillery producing approximately 20 million liters of ethanol per year.

Source: Coque e Alcool da Madeira S/A (1983) in Howard Geller, "Ethanol Fuel from Sugar Cane in Brazil," *Annual Review of Energy* 10 (1985), 147.

The cited studies show that ethanol production is determined largely by the agricultural technology utilized , i.e., how one grows and harvests the sugarcane and to a lesser extent, the industrial technology used in the distillation of ethanol. The traditional ethanol distilleries are linked to the mountainous land of the rural northeast, an area which is economically poorer and which has more agriculture labor than the modern ethanol distilleries. The modern ethanol distilleries are located in the more urban C/S, an area which has overall greater resources, superior land quality, and a shortage of agricultural workers. These differences directly affect employment requirements of the ethanol distilleries.[128]

Employment associated with modern and traditional ethanol production is a function of sugarcane production and distillation technology investment. Ethanol production and agricultural technologies are inextricably linked. The policy implications suggest that the social and economic viability of rural communities may affect the urban areas. For example, if the traditional technologies are not supported they may not be able to prevent people moving to urban areas. The loss of agricultural labor may mean that the traditional technologies may have to consider greater mechanization in the planting and harvesting of sugarcane for ethanol production.

F. Investment per Worker

The ethanol sector has relatively low investment costs associated with employment compared to different sectors of the economy. Table 15 shows the average investment necessary per job for various industries. Direct job creation in the industrial sector requires an investment of $44,000 per person per year. Capital-intensive industries like mineral product or paper and pulp industries typically require

[128]Rask, "The Social Costs of Ethanol Production in Brazil: 1978-1987," 630.

$70,000. Oil refining-petrochemical operations require the greatest investment, $220,000 per person per year. The ethanol industry has investment costs of $11,000 per person, which is the lowest of the different industries.

Investment costs associated the ethanol industry are low due to low capital and fixed cost requirements. Estimates for investment requirement per permanent job in the ethanol sector (which includes capital costs for ethanol production, lands costs as well as the investment in distillery and farm equipment), range from $23,000-$28,000 per person per year in the C/S region and $6000 - $7000 per person/year in the N/E region.[129]

Table 15. Investment per permanent job.

| Sector | Investment per Job ($US) |
|---|---|
| | |
| Chemical and Petrochemical | 220,000 |
| Metallurgy | 145,000 |
| Capital Goods | 98,000 |
| Automobile Industry | 91,000 |
| Intermediate Goods | 70,000 |
| Consumer Goods | 44,000 |
| Proalcool (agriculture + industry) | 11,000 |

Source: Plinio Nastari, "Turbulence Marks Brazil's Alcohol Program" *Fuel Reformulation*, (January/February 1992): 52.

[129]Nastari, "Turbulence Marks Brazil's Alcohol Program," 52.

## G. Qualitative Aspects

The qualitative aspects of employment associated with the ethanol industry are mixed. On the positive side, sugarcane laborers in Sao Paulo (C/S region) receive higher wages than 80% of other agricultural laborers, 50% of service laborers, and 40% of industry laborers.[130] However, working conditions in the N/E region are not as good, but are reported to be improving. Seasonality associated with sugarcane production has resulted in low salaries, poor working and living conditions, as well as the lack of benefits for workers. Recently, special legislation requires that 1% of the net sugarcane prices and 2% of the net ethanol price be allocated for the healthcare and educational benefits of sugarcane workers.[131] The qualitative conditions of sugarcane employment will continue to challenge the sugarcane industry in the N/E region as the increasing social costs approach the costs of mechanization.

The ethanol industry is highly labor intensive compared to many sectors of the economy. It has low investment employment costs and consequently provides significant job possibilities. While the traditional ethanol distilleries provide the greatest number of jobs, both types of distilleries offer meaningful employment because of the agricultural and industrial linkages of the ethanol industry. However, the working conditions of the traditional distilleries have historically been poor, but

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[130]Goldemberg *et al*, "The Brazilian Fuel Alcohol Program," 855.

[131]Ibid., 856.

are improving because of social legislation. Therefore, the overall employment effects associated with ethanol production are very positive.

SECTION TWO: DISTRIBUTION OF ETHANOL PRODUCTION

Ethanol production capacity in Brazil is approximately 16 billion liters. Table 16 shows the distribution of ethanol production by region and type of distillery. Ethanol processing occurs predominantly in the C/S region which includes Sao Paulo and Rio de Janeiro. This area accounts for 62% of total capacity. The N/E area which covers Pernambuco and Alagoas is second with 20% of production capacity, followed by the Centerwest (10%), the South (7%), and the North with 1% of the total ethanol production capacity.

The regional production output has shifted over two time periods: the 1978-79 crop and the 1986-87 crop. The N/E region increased its share from 16.5% in the 1978-79 period to 20.9% in the 1986-87 period; the C/S regional contribution declined from 80.3% to 66.5% during the same period.

Table 16. Production capacity of ethanol by region and type of distillery.

| Region | Number of Annexed Distilleries | Annexed Distillery Production Capacity | Number of Autonomous Distilleries | Autonomous Distillery Production Capacity | TOTAL Number of Distilleries | TOTAL Production Capacity |
|---|---|---|---|---|---|---|
| North (N/E Area) | 1 | 5.4 | 6 | 107.5 | 7 | 112.9 |
| Northeast (N/E Area) | 104 | 1855.0 | 62 | 1425.1 | 166 | 3280.0 |
| Centerwest (C/S Area) | 5 | 107.0 | 59 | 1468.9 | 64 | 1575.9 |
| Southeast (C/S Area) | 173 | 6204.7 | 216 | 3979.6 | 389 | 10184.3 |
| South (C/S Area) | 8 | 217.5 | 51 | 969.4 | 59 | 1186.9 |
| BRAZIL | 291 | 8389.6 | 394 | 7950.5 | 685 | 16340.1 |

Source: CENAL, *The National Alcohol Program*, (Brasilia, Brazil: CENAL,1988), 11.

Ethanol yields in 1977 were 2,663 liters per hectare, growing to 3,811 liters per hectare in 1985, an average annual increase of 4.3%. During the same period, agriculture productivity increased 16% (measured in tons of cane per hectare) and industrial productivity increased 23% (measured in liters of ethanol per ton of cane). By 1989, the average yield in the state of Sao Paulo was 4,700 liters of ethanol per hectare.[132] Table 17 outlines the agricultural and industrial productivity of each

[132]Goldemberg *et.al.*, "The Brazilian Fuel-Alcohol Program," 848.

region. Agricultural productivity increased most dramatically in the South, Southeast, and Centerwest regions. Industrial productivity measured in liters per ton of sugarcane increased significantly in each region.

Table 17. Evolution of agricultural and industrial productivity.

| Region | Agricultural Productivity (tons of cane/ha. Cultivated) | | | | Industrial Productivity (liters/tons of cane) | | | |
|---|---|---|---|---|---|---|---|---|
| | 77-78 | 84-85 | 86 | % increase | 77-78 | 84-85 | 86 | % increase |
| Northeast | 44.4 | 46.0 | 47.0 | 5.9 | 50.6 | 61.6 | 63.7 | 25.9 |
| Southeast | 48.4 | 57.1 | 57.3 | 18.4 | 61.6 | 70.5 | 73.8 | 19.8 |
| South | 38.5 | 60.0 | 63.0 | 63.6 | 55.1 | 65.4 | 69.3 | 25.8 |
| Centerwest | 28.5 | 43.9 | 46.7 | 63.9 | 53.7 | 68.3 | 69.3 | 29.4 |
| Brazil | 46.4 | 53.1 | 53.9 | 16.2 | 57.4 | 67.8 | 70.7 | 23.2 |

Source: CENAL, *The National Alcohol Program*, (Brasilia, Brazil: CENAL,1988), 23.

SECTION THREE: CONCLUSION

Brazil is the world's largest sugarcane producer. Sugarcane production tripled between 1975 and 1995, from 70 million tonnes in 1975 to an estimated 226 million tonnes in the 1996-97 season. About 66% of all sugarcane produced is used for ethanol. Ethanol production is highly labor intensive because of the link to the agriculture sector. Two types of distilleries are used to produce ethanol. Annexed distilleries are usually attached to sugar mills and have flexibility in switching production between sugar and ethanol. Autonomous distilleries are independent, stand-alone plants that produce ethanol exclusively. The development and expansion of autonomous distilleries began in 1979. The ethanol sector generates the greatest employment of the ethanol, oil, electricity and coal energy sub-sectors and has the lowest investment cost per worker.

The choice of production technology has very different employment and distribution consequences. The traditional ethanol sector is more labor intensive and is found in more rural areas; the modern ethanol sector is relatively more capital intensive and located in more urban areas. Today, the traditional ethanol distilleries account for approximately 20% of total ethanol production and employ roughly 2 to 8 times more workers than the modern ethanol distilleries.[133] The next chapter provides a cost assessment of Brazil's alternative fuel program.

[133]Rask, "The Social Costs of Ethanol Production," 629-630.

# CHAPTER FIVE

# THE COST OF ETHANOL PRODUCTION

Analyzing the economic efficiency of Brazil's alternative transportation fuel program is very difficult because of data limitations and cost assumptions. The true costs of ethanol production are hard to calculate because of complex production subsidies, tariff structures, and consumption incentives. Cost assessments are also complicated by volatile exchange rates and international oil prices. Since the program's beginning, ethanol cost estimates have ranged from $20 to $90 per barrel of gasoline replaced. Recent studies show that the costs of production have declined significantly. Nonetheless, current oil prices render Brazil's ethanol program economically unviable.

This chapter attempts to provide a cost analysis of the *Proalcool* program. Section one shows the costs of ethanol production, and is based on two very recent studies. Section two presents the government subsidies and incentives to the ethanol industry. Section three summarizes several evaluations of the *Proalcool* program.

## SECTION ONE: ETHANOL PRODUCTION COSTS

### A. Goldemberg Analysis

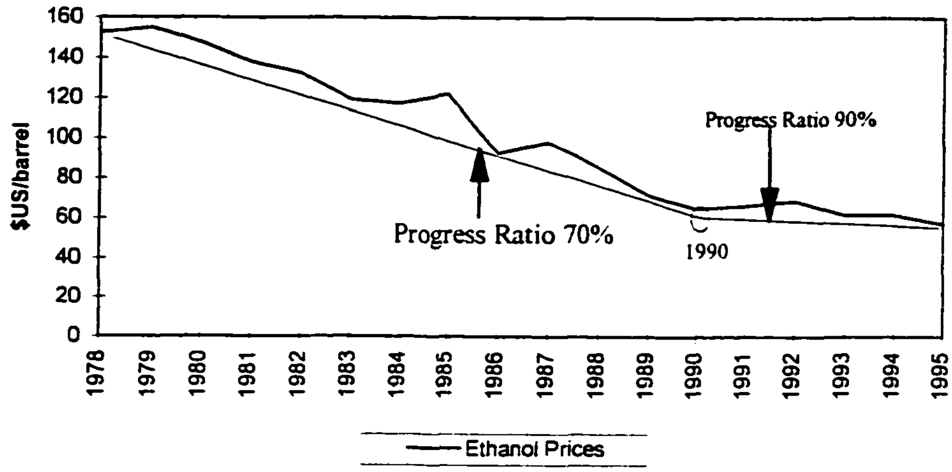
Jose Goldemberg analyzed an indicator called the progress ratio for the evolution of ethanol costs in Brazil between 1978 and 1995. The progress ratio explains the decline in prices of any manufactured product. The price decrease is a result of the learning curves which reflect the gains due to technological progress, economies of scale, and organizational learning.[134] For example, a progress ratio of 80% means that the cost declines 20% for each doubling of production. The lower the progress ratio the faster the decline in cost. Figure 14 shows the progress ratio for the cost of ethanol production between 1978 and 1995.

Goldemberg concludes, based on the data shown in Figure 14 and Table 18, that between 1982 and 1990, the cost of ethanol declined rapidly according to a progress ratio of 70% and afterwards declined more slowly ( a progress ratio of 90%).[135]

[134]Jose Goldemberg "The evolution of ethanol costs in Brazil," *Energy Policy* 24, no.12 (December 1996): 1127.

[135]Ibid.

FIGURE 14. EVOLUTION OF ETHANOL COSTS IN BRAZIL

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Goldemberg states two ways that further technological progress could lower costs: 1) advances in sugarcane production and in the industrial phase of ethanol production which could lead to a reduction in cost of 23.1%, and 2) the efficient use of excess bagasse for the cogeneration of electricity with ethanol production.[136]

[136]Ibid., 1128.

Table 18. Brazilian ethanol production and costs

| Year | Ethanol Production ($10^6$ $m^3$)[a] | Accumulated Production ($10^6$ $m^3$) | Price paid to producers (US$m$^3$)[b] | Price paid to producers (US$/barrel) |
|---|---|---|---|---|
| up to 1978 | 2673 | 2673 | 952.41 | 152.3 |
| 1979 | 2854 | 5527 | 968.88 | 155 |
| 1980 | 3676 | 9203 | 422.33 | 147.5 |
| 1981 | 4207 | 13410 | 862.42 | 138 |
| 1982 | 5618 | 19028 | 827.09 | 132.3 |
| 1983 | 7951 | 26979 | 745.45 | 119.3 |
| 1984 | 9201 | 36180 | 733.04 | 117.2 |
| 1985 | 11563 | 47746 | 764.07 | 122.2 |
| 1986 | 9983 | 57729 | 581.23 | 93 |
| 1987 | 12340 | 70069 | 612.5 | 98 |
| 1988 | 11523 | 81592 | 532.54 | 85.2 |
| 1989 | 11629 | 93221 | 446.84 | 71.5 |
| 1990 | 11518 | 104739 | 406.13 | 65 |
| 1991 | 12863 | 117602- | 413.4 | 66.14 |
| 1992 | 11766 | 129368 | 428.53 | 68.6 |
| 1993 | 11195 | 140566 | 385.04 | 61.6 |
| 1994 | 12512 | 153078 | 384.33 | 61.5 |
| 1995 | 12647 | 165725 | 345.15 | 56.82 |

Source: [a]1995 National Energy Balance, Ministry of Mines and Energy Brazil: [b]"Reprinted from *Energy Policy* 24, no. 12, Jose Goldemberg, The evolution of ethanol costs in Brazil, 1128, © (December 1996), with permission from Elsevier Science. "

B. Rask Analysis

Kevin Rask performed a social cost analysis of the Brazilian ethanol industry between 1978 and 1987 based on the I.M.D. Little and J.A. Mirrlees approach. He took surveys conducted by the Institute of Sugar and Alcohol (IAA) which provided the private costs of ethanol production and assigned shadow prices to the private costs (prices) that were equivalent to market prices.

Shadow prices were assigned to the transportation sector, capital subsidies, and market wage rates, as well as tariffs on farm machinery and equipment, fertilizer, and most chemicals. Once the private costs were adjusted to their social values, Rask then compared them with the benefit of decreased petroleum imports.

The most important finding of Rask's cost-benefit analysis is that ethanol can be an efficient substitute for oil when world oil prices are in the range of $21-$25 per barrel. Previous studies estimate that ethanol is economic only when oil prices are over $30. He also attributes the trend of falling costs to falling real wages in Brazilian agriculture and less to technological progress.

Table 19 shows the social costs of ethanol in the C/S region between 1978 and 1987. Rask finds that during the early years of the program, ethanol production by autonomous distilleries in the C/S was extremely costly. The high oil prices in the early 1980s combined with the reductions in social costs of ethanol production made ethanol an efficient alternative to gasoline between 1983 and 1985. The decline of oil prices in the 1980s rendered ethanol production inefficient. The results of the 1985-1987 sample suggest that oil prices must be in the $23 to $25 per barrel range before production in the C/S by autonomous distilleries can be considered economically efficient.

The C/S annexed distilleries, being smaller and initially more efficient than the newer autonomous distilleries, record a lower overall social cost. They produced ethanol efficiently between 1980 and 1985, the years of the highest oil prices.

Table 19. Social costs of ethanol production, Brazil Center-South region, 1978-1987.

| | '78 | '79 | '80 | '81 | '82 | '83 | '84 | '85 | '86 | '87 |
|---|---|---|---|---|---|---|---|---|---|---|
| Autonomous Ethanol cost Per liter | | | | | | | | | | |
| Agriculture | 2.23 | 3.42 | 6.17 | 12.0 | 21.1 | 49.7 | 107 | 476 | 1.38 | 3.32 |
| Industry | 1.84 | 3.22 | 5.48 | 10.8 | 15.2 | 37.0 | 132 | 316 | 0.70 | 1.92 |
| Total | 4.07 | 6.64 | 11.65 | 22.8 | 36.3 | 86.7 | 239 | 792 | 2.08 | 5.24 |
| TOTAL HYDROUS EQUIVALENT | | | | | | | | | | |
| Per barrel ($US) | 43.5 | 47.5 | 41.1 | 49.4 | 39.3 | 28.3 | 25.1 | 23.8 | 25.3 | 26.4 |
| Oil Price ($US/barrel) | 12.7 | 17.3 | 28.7 | 32.5 | 33.5 | 29.3 | 28.5 | 26.4 | 11.6 | 16.6 |
| Weighted cost | 35.2 | 39.3 | 34.9 | 43.9 | 37.5 | 27.2 | 24.2 | 23.3 | 24.8 | 26.0 |
| Annexed-Ethanol cost Per liter | | | | | | | | | | |
| Agriculture | 2.14 | 3.11 | 5.28 | 12.4 | 24.4 | 48.5 | 156 | 660 | 1.49 | 3.39 |
| Industrial | 0.94 | 2.18 | 3.13 | 4.98 | 6.26 | 14.4 | 73 | 204 | .33 | 1.10 |
| Total | 3.08 | 5.29 | 8.41 | 17.4 | 30.7 | 62.9 | 229 | 864 | 1.82 | 4.49 |
| TOTAL HYDROUS EQUIVALENT | | | | | | | | | | |
| Per barrel | 31.6 | 36.4 | 27.6 | 36.0 | 32.0 | 18.6 | 23.9 | 26.6 | 21.5 | 21.8 |
| Oil Price (US$/barrel) | 12.7 | 17.3 | 28.7 | 32.5 | 33.5 | 29.3 | 28.5 | 26.4 | 11.6 | 16.6 |
| Weighted cost | 25.6 | 30.5 | 23.4 | 31.9 | 30.1 | 17.6 | 23.0 | 25.5 | 20.4 | 21.0 |

Source: . Kevin Rask, "The Social Costs of Ethanol Production in Brazil: 1978-1987," *Economic Development and Cultural Change* 43, no. 3 (1995): 639. © by The University of Chicago. Oil prices are taken from IMF. Ethanol costs are in Cr$/US$ for 1978-85, and cruzados for 1986-1987. Weighted social cost (US$/barrel) of production, which takes into account the percentage of anhydrous produced (17%-21% more efficient and 3% more costly) relative to hydrous ethanol.

Table 20 shows the social costs of ethanol in the N/E region between 1978 and 1987. The results from the N/E are in stark contrast to those of the C/S. While a comparison of ethanol distillation costs reveals relatively small differences between

Table 20. Social costs of ethanol production, Brazil Northeast region, 1978-1987.

| | '78 | '79 | '80 | '81 | '82 | '83 | '84 | '85 | '86 | '87 |
|---|---|---|---|---|---|---|---|---|---|---|
| Autonomous Ethanol cost per liter | | | | | | | | | | |
| Agriculture | 4.08 | 5.84 | 13.5 | 29.6 | 52.3 | 126 | 277 | 981 | 2.19 | 8.04 |
| Industry | 1.84 | 3.22 | 5.48 | 7.6 | 30.8 | 50 | 164 | 560 | 1.34 | 3.39 |
| Total | 5.92 | 9.06 | 19.0 | 37.2 | 83.1 | 176 | 441 | 1541 | 3.53 | 11.43 |
| HYDROUS EQUIVALENT | | | | | | | | | | |
| Per barrel (US$) | 65.6 | 67.4 | 71.8 | 85.2 | 99.0 | 64.6 | 52.3 | 52.7 | 46.8 | 64.8 |
| Oil Price ($US barrel) | 12.7 | 17.3 | 28.7 | 32.5 | 33.5 | 29.3 | 28.5 | 26.4 | 11.6 | 16.6 |
| Weighted cost | 53.1 | 56.0 | 62.9 | 80.2 | 92.3 | 61.3 | 50.3 | 51.5 | 45.5 | 63.2 |
| Annexed Ethanol cost per liter | | | | | | | | | | |
| Agriculture | 3.85 | 5.36 | 12.7 | 34.1 | 63.1 | 97.4 | 328 | 1117 | 3.11 | 8.21 |
| Industrial | 1.52 | 3.56 | 4.63 | 7.76 | 15.5 | 26.6 | 102 | 204 | .72 | 1.99 |
| Total | 5.37 | 8.92 | 17.3 | 41.9 | 78.6 | 124 | 430 | 1321 | 3.83 | 10.2 |
| HYDROUS EQUIVALENT | | | | | | | | | | |
| Per barrel (US$) | 59.1 | 66.2 | 64.7 | 97.2 | 93.3 | 43.5 | 50.8 | 44.2 | 51.2 | 57.2 |
| Oil Price (US$/barrel) | 12.7 | 17.3 | 28.7 | 32.5 | 33.5 | 29.3 | 28.5 | 26.4 | 11.6 | 16.6 |
| Weighted cost | 47.9 | 56.4 | 55.2 | 87.4 | 81.3 | 40.5 | 48.2 | 43.2 | 49.9 | 55.8 |

Source: Kevin Rask, "The Social Costs of Ethanol Production in Brazil: 1978-1987," *Economic Development and Cultural Change* 43, no. 3 (1995): 639. © by The University of Chicago. Oil prices are taken from IMF. Ethanol costs are in Cr$/US$ for 1978-85, and cruzados for 1986-1987. Weighted social cost (US$/barrel) of production, which takes into account the percentage of anhydrous produced (17%-21% more efficient and 3% more costly) relative to hydrous ethanol.

the N/E and C/S, the costs of sugarcane production are significantly higher in the N/E. Driven by the large labor requirements of the hillside sugarcane farming (hand cutting and transport off the field), the agricultural costs, and subsequently, the total social costs of ethanol in the N/E are over twice those in the C/S.

Ethanol from the N/E region is an efficient oil substitute only when world oil prices are in the range of $50-$60 per barrel. This region produces 20% of Brazil's ethanol. The government directly subsidizes the purchase price of ethanol in the N/E, paying approximately double the purchase price paid in the C/S. The production in the N/E is used as a form of government transfer to this depressed region.

Rask's cost analysis does capture significant cost reductions between 1978 and 1987; however, the methodology provides no explanation of their origin. The costs per barrel drop from the $40s to the $30s and finally settle around the low $20s in the mid-late 1980s. Rask questions the source of the cost reductions: are the lower costs due to significant efficiency gains which proponents cite, or are they due to falling real factor prices, a by-product of the deep recession which Brazil entered in the early 1980s? He finds causal evidence to support both explanations. Sugarcane yields have increased from 60 tons/hectare to 75 tons/hectare in the modern ethanol sector. Industrial yields have increased from 60-65 liters/ton to 70-75 liters/ton.[137] While this evidence supports the claims of increased technical efficiency, there is also

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[137] Rask, "The Social Costs of Ethanol Production In Brazil: 1978-1987," 646.

evidence of falling real factor prices. The most consistent factor in the price trend is falling real wages across various states in Brazil. Agriculture labor costs are a substantial portion of the total cost of ethanol production. Falling wages are likely some part of the overall drop in unit costs of production. Rask's results suggest the important force behind falling ethanol costs has been labor costs. This suggests that as economic development occurs, and real wages rise, the future cost-benefit of ethanol production will be negatively impacted. Rask's study does not attempt to incorporate distributional or pollution effects.

## SECTION TWO: PRODUCTION AND CONSUMPTION INCENTIVES

The major inputs to ethanol production are labor, capital, farm machinery and equipment, fertilizers, transportation services, and chemicals.[138] Comparing the price of oil imports to the costs of ethanol production is complicated by a number of factors, namely subsidized capital investments, production subsidies, tariffs, exchange rates, and consumption incentives.

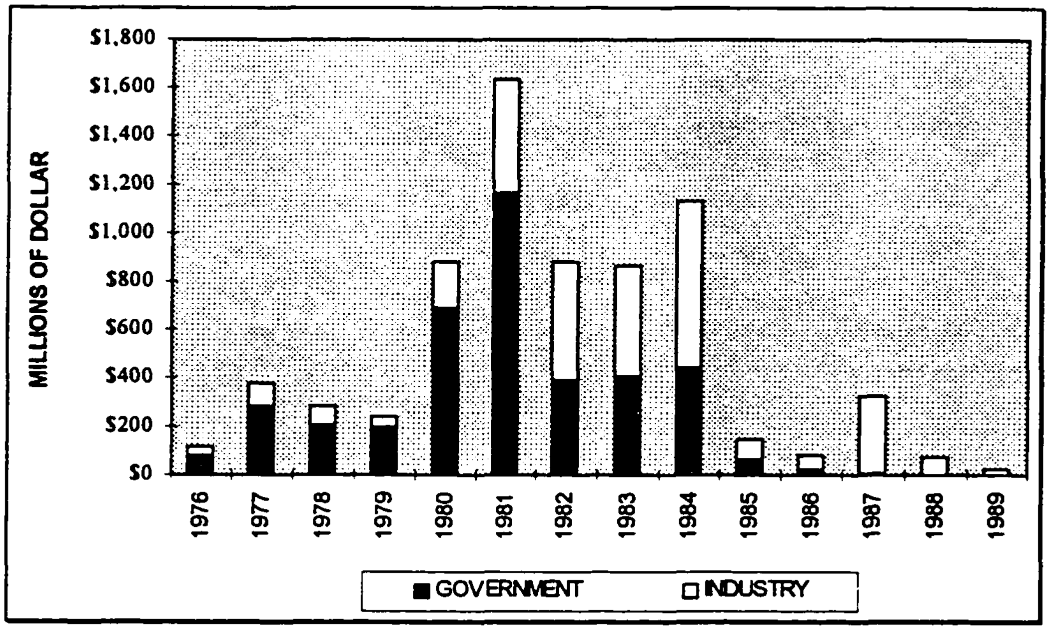
### A. Capital Investment Subsidies

Total investment in ethanol distilleries between 1975 and 1989 reached $7 billion, of which $4 billion was from the government and $3 billion was from entrepreneurs' resources. Investment in agriculture and industry was $2.2 billion and $4.8 billion respectively. Figure 15 shows the total annual investment between 1975

[138] Ibid., 633.

and 1989. In 1981, the World Bank allocated $250 million of which $223.3 million was actually disbursed to partially finance 67 distilleries.[139]

FIGURE 15. ETHANOL INDUSTRY INVESTMENT BY GOVERNMENT AND INDUSTRY, $10^6$ DOLLARS.




Source: CENAL, *The National Alcohol Program*, (Brasilia, Brazil: CENAL,1988), 18. Datagro, 1992.

B. Sugar and Ethanol Production Subsidies

The sugar and ethanol industries also receive subsidies. A federal agency known as the Sugar and Alcohol Institute (IAA) regulates all sugar production and subsidizes producers. The IAA sets production quotas for sugarcane and sugar producers. The IAA controls domestic sugar prices by setting retail sugar prices

[139]World Bank, *Project Performance Audit Report*, 55.

higher than the world sugar price while exported sugar prices are subject to international agreement. The IAA also determines sugar and ethanol production levels by annexed and autonomous ethanol distilleries. The IAA has monoposonistic power in buying sugar and ethanol as well as monopolistic power in exporting them.[140]

The IAA gives more preferential subsidy treatment to the N/E region than to the C/S region because of its lower productivity in producing sugar and ethanol. Prices account for technological differences associated with producing ethanol and sugar. Apart from the years 1974 and 1975, a lack of information exists to estimate the effects of price on ethanol producers. Nonetheless, an implicit subsidy on sugarcane production exists. In 1974 and 1975 the IAA established an explicit price subsidy for sugarcane production. The average subsidy was Cr$10.06/ton of sugarcane in 1974 and Cr$21.38/ton of sugarcane in 1975 for production in the C/S region.[141]

C. Tariffs

Tariffs also complicate the cost assessments of ethanol production. Tariffs are levied on automobiles, trucks, fertilizer, farm machinery and equipment and most chemicals. Table 21 provides the tariff rates for the inputs of ethanol production.

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[140]World Bank, *Trade, Exchange Rate, and Agricultural Pricing Policies in Brazil,* 106.

Table 21. Tariff schedule for selected ethanol inputs: 1976-1988, (%).

| | Fertilizer | | | Agriculture | | | Transport | |
|---|---|---|---|---|---|---|---|---|
| | Super-Phosphate | Urea | Potassium Chloride | Chemical | Machines | Equipment | Auto-mobiles | Truck |
| 76-78 | 40 | 15 | 0 | 15 | 30 | 40 | 85 | 105 |
| 79-86 | 20 | 15 | 0 | 15 | 30 | 55 | 105 | 105 |
| 87-89 | 20 | 15 | 0 | 15 | 45 | 45 | ... | ... |

Source: Kevin Rask, "The Social Costs of Ethanol Production in Brazil: 1978-1987," *Economic Development and Cultural Change* 43, no. 3 (1995): 635. © by The University of Chicago.

D. Foreign Exchange Savings

Table 22. Brazil's official and equilibrium exchange rates between 1974 and 1987.

| Year | Official Exchange Rate | Equilibrium Exchange Rate |
|---|---|---|
| 1974 | 6.84 | 7.66 |
| 1975 | 8.20 | 8.99 |
| 1976 | 11.00 | 11.85 |
| 1977 | 14.00 | 14.73 |
| 1978 | 18.00 | 19.10 |
| 1979 | 27.00 | 29.04 |
| 1980 | 53.00 | 57.58 |
| 1981 | 93.00 | 99.68 |
| 1982 | 180.00 | 197.38 |
| 1983 | 577.00 | 609.01 |
| 1984 | 1,848.00 | 1,847.36 |
| 1985 | 6,200.00 | 6,212.76 |
| 1986 | 13.66 | 14.11 |
| 1987 | 39.23 | 39.55 |

Note: Exchange rates are in Cr$/US$ for 1974-85 and cruzados/US$ for 1986-87.
Source: Kevin Rask, "The Social Costs of Ethanol Production in Brazil: 1978-1987," *Economic Development and Cultural Change* 43, no. 3 (1995): 635. © by The University of Chicago.

[141] Ibid.,106-110.

The cumulative foreign exchange savings and export earnings of ethanol have been significant. Table 23 shows the quantity and value of imported gasoline replaced by ethanol and ethanol's export earnings between 1976 and 1987.

Table 23. Quantity and value of imported gasoline replaced by ethanol, 1976-1987.

| Year | Ethanol production $10^6$ liters, (PJ) | Equivalent cost of imported gasoline (US$ millions) | Value of the Brazilian exports of gasoline & ethanol (US$ millions) |
|---|---|---|---|
| 1976 | 642.2 (13.6 PJ) | 61.0 | 24.8 |
| 1977 | 1,387.7 (29.4 PJ) | 133.9 | 67.2 |
| 1978 | 2,359.1 (49.9 PJ) | 283.0 | 156.6 |
| 1979 | 3,448.3 (73.0 PJ) | 865.3 | 383.1 |
| 1980 | 3,676.1 (77.8 PJ) | 1017.5 | 789.1 |
| 1981 | 4,206.7 (89.1 PJ) | 1010.4 | 689.4 |
| 1982 | 5,617.9 (118.9 PJ) | 1314.8 | 902.5 |
| 1983 | 7,950.3 (168.3 PJ) | 1521.0 | 1,049.5 |
| 1984 | 9,201.0 (194.8 PJ) | 1587.2 | 1,354.3 |
| 1985 | 11,772.9(249.3PJ) | 2077.5 | 1,470.2 |
| 1986 | 9,965.2 (210.9 PJ) | 1149.5 | 1,067.7 |
| 1987 | 12,310.1(260.6PJ) | 1458.5 | 629.4 |
| Total | 72,538(1,535.8PJ) | 12,480.2 | 8,583.8 |

Source: CENAL, *The National Alcohol Program*, (Brasilia, Brazil: CENAL,1988), 20.

The government places a tax on oil imports. In 1984, the government applied a 20% surcharge to companies needing currency to purchase imports because incremental oil imports were debt-financed.[142] Currently, each equivalent barrel of gasoline carries a tax of 25 US dollars.[143] Ethanol replaced 12.3 billion liters (260.6 PJ) of gasoline equivalent in 1987 alone, which was the equivalent value of the cost of importing 404 million barrels of gasoline. Ethanol production saved $12.5 billion in foreign exchange between 1976 and 1987. During the same period, the value of gasoline and ethanol exports was $8.5 billion.

E. Fuel Pricing

Another government incentive that influences a cost assessment of ethanol production is the price of anhydrous and hydrous fuel ethanol. Initially, the price of hydrous ethanol was capped at 65% of the price of anhydrous ethanol because it contained two-thirds the energy content of anhydrous. The price of hydrous ethanol has always been lower than anhydrous ethanol, fluctuating between its lowest price of 52% and 75% of anhydrous ethanol's price. Currently, hydrous ethanol's selling price is 15% to 20% cheaper than anhydrous ethanol.[144]

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[142]Goldemberg, *Energy Strategies for Developing Countries*, 249.

[143]Carvalho, "The prospects for ethanol production in Brazil," 292.

[144]Ibid.

F. Ethanol and Gasoline Prices

The cost of ethanol production is measured against present oil prices which are very different from the oil price projections at the beginning of the program. Actual crude oil prices have been significantly lower than what was projected in 1980. While oil prices have declined between 1981 and 1985, it was the oil price collapse in 1986 which threatened the continued viability of the ethanol program. To compare the cost of a barrel of ethanol and a barrel of gasoline, one must add to the price of a barrel of imported oil, the shipping and refining costs, and the current surcharge per barrel of gasoline ($25/barrel).[145] Oil prices are central to the ethanol program and continue to affect the program's economic viability.

SECTION THREE: EVALUATIONS OF THE ETHANOL PROGRAM

Brazil's alternative transportation fuel program has been widely critiqued. A number of studies assess the employment and economic ramifications of the ethanol industry. The most recent analyses include the environmental effects; however, the income distribution consequences have not been empirically evaluated. Furthermore, most of the analyses within the literature account for the direct effects of the alternative fuel program, but do not quantify the program's indirect effects. While the technical implementation of the ethanol program has been a success, a quantification of the income distribution and the greenhouse gas consequences have been limited.

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[145] Ibid.

Luiz Carvalho of the Sugar and Alcohol Industries Association of Sao Paulo analyzed the developments in the ethanol industry since 1975 and considered its future potential.[146] His assessment took into account the environmental benefits associated with the greenhouse effect and pollution reduction in large cities. He concluded that although lower oil prices have created difficulties for the ethanol program in the last few years, the future remains promising. The demand for ethanol-blended gasoline is rising and it is estimated that ethanol production will increase by the year 2000 from the current 12.7 billion liters (1994/95) to about 14.6 billion. Sugar exports are likely to be about 5 million tonnes into the international market; at the same time, the use of ethanol will be helping the country towards clean air, improving the health of the people and reducing the overheating of the atmosphere.

Goldemberg, Monaco, and Macedo most recently have provided an social cost-benefit analysis of the Brazilian fuel-ethanol program which includes the environmental effects.[147] It concludes that the promotion and use of ethanol has achieved multiple objectives, notably: lowered fuel imports, increased job creation, and reduced air pollution. An additional contribution of the program has been the accelerated pace of technological development, thus the creation of a technological environment for the agro-industry which has introduced high-level production

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[146]Ibid., 289-294.

[147]Goldemberg *et. al.*, "The Brazilian Fuel-Alcohol Program," 841-863.

techniques to the agricultural sector, allowing the agricultural sector to become efficiently integrated with the industrial sector.

The World Bank has conducted several assessments of Brazil's ethanol industry as part of the evaluation process of its loans for the program. In 1990, a World Bank audit determined that the major shortcoming of the cashflow analysis was that the sensitivity was performed only against changes in location, land value, and average yield. There was no discussion of sensitivity to decreases in oil prices, neither was there a benchmark price of oil against which the project could be judged economically unviable.[148] The maintenance of massive subsidies to ethanol producers, even when economic signals indicated that they were not needed, became an invitation to create more capacity than was merited, and compounded the difficulties of adjusting to the post 1986 oil price realities.[149] Finally, correct relative prices between fuel substitutes in inter-fuel substitution projects is of cardinal importance. Relative prices among different fuel choices directly affects fuel consumption levels. Fuel pricing policies favoring hydrous alcohol over anhydrous alcohol resulted in the "over-substitution" of "gasohol" (anhydrous alcohol) by

[148]World Bank, *Project Performance Audit Report*, 79.

[149]Ibid., vii.

hydrous alcohol. The consumer price for hydrous alcohol was much lower than warranted on economic cost grounds.[150]

In 1980, the World Bank analyzed ethanol production from biomass in developing countries based on Brazilian data. The major conclusion is that the "relative merits of alcohol production will vary among countries depending on the specific economic parameters of their agricultural, industry, and energy sectors, the most critical of which are cropping patterns, economic costs of biomass, plant capital costs, distribution costs and fuel sources".

The International Labour Office (ILO) has also examined Brazil's ethanol industry. Armand Pereira completed the first study in 1986. He analyzed the extent to which *Proalcool* contributed to foreign currency savings, employment creation, and income redistribution. In addition, his study reviewed the technological and economic aspects of ethanol production. The study, which covered the period 1975 to 1980, concluded that *Proalcool* had a positive balance of payments savings of $520 million in 1980 alone; it created direct employment of 41,000 permanent and 83,000 seasonal workers. The study also found that *Proalcool* had contributed to a concentration in personal and inter-regional income distribution during its first five year period. A second study prepared for the ILO on the socioeconomic aspects of renewable energy technologies was published in 1988. It includes a chapter on the

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[150]Ibid.

macroeconomic impacts of ethanol production in Brazil which is based on Pereira's 1986 study. This study concluded that the *Proalcool* program had balance of payments savings, generated greater employment, and improved income distribution as well as regional inequality over the first 5 year period. The ILO studies used surveys to consider only the direct effects associated with ethanol production, particularly for employment and income distribution. The current research analyzes both the direct and indirect effects of the ethanol program using a social accounting matrix framework.

In 1988, the U.S. Department of Energy published a report on the use of alternative fueis worldwide. The major conclusion regarding Brazil's development of the ethanol industry was that while the technical and implementation success of *Proalcool* was certain, critics vary in their economic valuation. "The foreign exchange savings from 1976 to 1985 are estimated to be $8.9 billion; government and industry investments are estimated to be $6.4 billion." There was no attempt to quantify the socioeconomic impacts.

In 1988, Daniel Sperling concluded that a definitive economic analysis was confounded by changing exchange rates and internal currency adjustment, complex subsidy arrangements, uncertain opportunity costs for land and capital, widely varying costs from one region to another, and foreign debt considerations. He states,

> "Clearly when oil prices dropped to $15 to $20 per barrel in 1986 and 1987, ethanol production became uneconomic. It is still not possible to determine whether the ethanol initiative was a mistake. The ethanol program provided indirect benefits to the economy of increased employment and industrial investment and has helped reduce the cost and risk of depending upon foreign oil. However, in the mid 1980s even with those benefits the ethanol program must be considered an economic failure. But who can say if this evaluation will still be valid in the 1990s".

Fred Moavenzadeh and David Geltner found that the Brazilian transport energy policy was successful from a physical perspective, but was shaky from an economic perspective. The backward linkages of the program have contributed to the development and production capability in related fields namely oil exploration and production and alcohol distillation equipment technology. Because of the strong research and development component of the alternative fuel program, further developments of offshore oil and alcohol may provide greater export opportunities from Brazil's capital industry and for its technology. They also concluded that international oil prices would rise and render the program economically feasible within a decade.

SECTION FOUR: CONCLUSION

Two recent cost assessments were presented. In the first study, Jose Goldemberg analyzed an indicator called the progress ratio to measure ethanol production costs in Brazil between 1978 and 1995. He concluded that the cost of ethanol production declined rapidly between 1982 and 1990, and declined more slowly between 1990 and 1995. He attributed the cost reductions to technological progress. He concluded that further cost reductions could be achieved through advances in sugarcane production and in the industrial phase of ethanol production. In addition, cost savings could be realized through more efficient use of excess bagasse for the cogeneration of electricity with ethanol production.

In the second study, Kevin Rask's social cost assessment of ethanol production between 1978 and 1987 was presented. Rask's cost analysis captured significant cost reductions between 1978 and 1987; however, the methodology provided no explanation of their origin. The costs per barrel drop from $40s to $30s and finally settle around the low $20s in the mid-late 1980s. He found that the lower costs were not due to significant efficiency gains, rather were due to falling agriculture labor costs. He concluded that as economic development occurs, and real wages rise, the future cost-benefit of ethanol production would be negatively impacted.

Any cost analysis of the ethanol program is difficult because of complex available data. The costs are affected by capital financing arrangements, subsidies, tariffs, and taxes associated with the major inputs, i.e. labor, capital, farm machinery and equipment, fertilizers, transportation services, and chemicals. These costs are not easily obtainable and complicate computing the real costs of ethanol production. Total investment in ethanol distilleries between 1975 and 1989 reached $7 billion, of which $4 billion was from the government and $3 billion was from entrepreneur's resources. The sugar and ethanol industries also received subsidies. A federal agency known as the Sugar and Alcohol Institute, IAA, regulates all sugar production and subsidizes producers. The IAA sets production quotas for sugarcane and sugar producers. Except for the years 1974 and 1975, a lack of information exists to estimate the explicit subsidies to ethanol producers. Nonetheless, an implicit subsidy on sugarcane production exists. Tariffs also complicate the cost assessments of ethanol production. Tariffs are levied on automobiles, trucks, fertilizer, farm machinery and equipment and most chemicals. Another complication is oil prices which are denominated in US dollars. In 1984, the government applied a 20% surcharge to imports because incremental oil imports were debt-financed. Currently, each equivalent barrel of gasoline carries a tax of 25 US dollars.

The cumulative foreign exchange savings and export earnings of ethanol have been significant. It has been estimated that ethanol production saved $12.5 billion in foreign exchange between 1976 and 1987. During the same period, the value of gasoline and ethanol exports was $8.5 billion. Finally, a government fuel ethanol pricing incentive has influenced the cost assessment of ethanol production. The price of hydrous ethanol has been lower than anhydrous ethanol (gasohol), fluctuating between its lowest price of 52% and 75% of anhydrous ethanol's price. Currently, the selling price of hydrous ethanol is 15% to 20% cheaper than anhydrous ethanol.

Comparing the cost of ethanol production to the price of imported petroleum overlooks a number of important factors. For several years incremental oil imports placed a number of strains on the Brazilian economy because they were debt-financed. Actual oil prices were very different to the oil price projections at the beginning of the program. Even though oil prices declined between 1981 and 1985, it was the oil price collapse in 1986 which threatened the continued viability of the ethanol program. Comparing the cost of a barrel of gasoline against the cost of a barrel of ethanol has to include the price of a barrel of imported oil, the shipping and refining costs, and the current surcharge per barrel of gasoline. Oil prices are central to the ethanol program and continue to affect the program's economic viability.

A number of assessments of Brazil's alternative fuel program exist by the World Bank, International Labour Organization, Brazilian trade organizations, and individual researchers. Almost all conclude that the biomass program, *Proalcool,* has been successful in terms of its technical implementation, foreign exchange savings, and employment creation. The major criticisms of the program are the opportunity cost of government support, as well as increasing regional and individual income inequality. A very limited number of empirical studies quantify the income distribution and greenhouse gas effects of the alternative fuel program. The oil price projections of the late 1970s did not materialize, this coupled with the record low oil prices of 1986, has presently rendered the ethanol program economically unviable.

The next chapter presents the methodology used to evaluate the socioeconomic, economic, and environmental differences of the two types of ethanol production technologies.

# CHAPTER SIX

## RESEARCH METHODOLOGY

The methodology used to test the hypotheses is the social accounting matrix framework. This methodology was selected because it is a superior economy-wide model that is capable of capturing an economy's social and economic interrelationships. Comparative static exercises relying on fixed price multipliers and structural path analysis show the employment and income effects resulting from changes in expenditure patterns due to changes in technology or government policies. Fixed price multipliers, (FPM), derived from a social accounting matrix model, are used to assess how changes in technology or government policies affect the ethanol sector in Brazil; and the structural path analysis decomposes the direct and indirect results of such changes upon the entire economic system. Calculating the FPM and using structural path analysis requires an accurate and detailed structure of the economy which a social accounting matrix provides.

## SECTION ONE: SOCIAL ACCOUNTING MATRIX

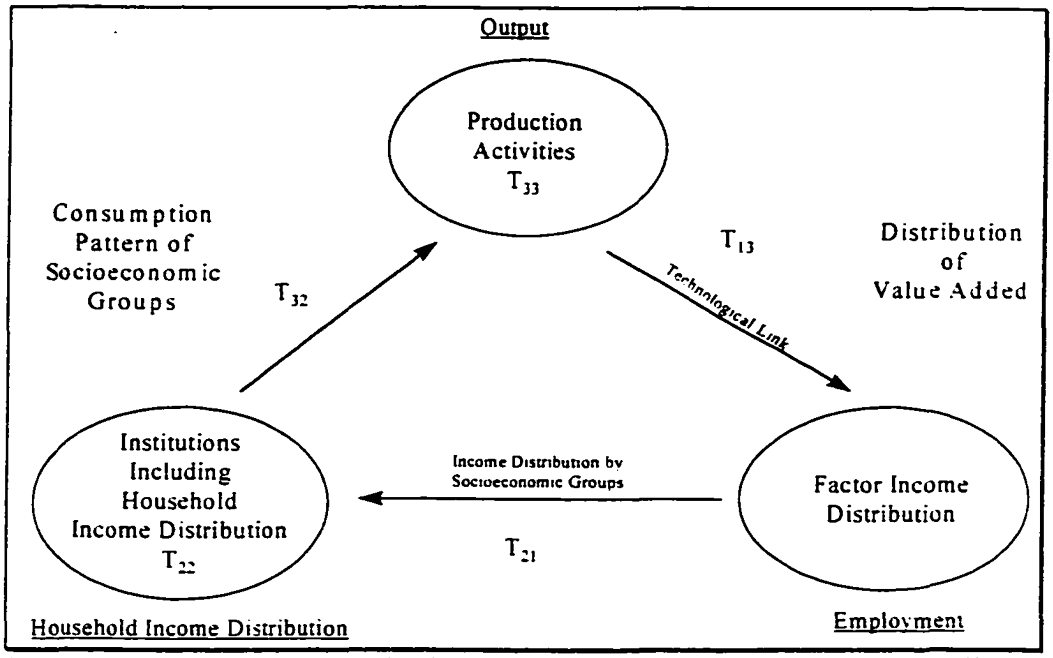
### A. SAM Framework

The social accounting matrix (SAM) was developed as a tool for social and economic planning.[151] A SAM is best visualized as a snapshot of an entire economy at a certain point in time. It is an open keynesian multisectoral framework which summarizes the interrelationships among the structure of production, output; the distribution of value-added going to the factors of production generated by the production activities, employment; and the income distribution by socioeconomic groups and the corresponding consumption and savings behavior of these socioeconomic groups. Figure 16 shows these interrelationships.

Figure 17 shows how a SAM is organized. The SAM is a data and classification system based on the accounting principle of total receipts equaling total expenditures. The interrelationships among the productive activities, value-added distributed to the factors of production, household income distribution, government and the rest of the world accounts are captured by rows and columns of a matrix. By convention the columns show the account expenditures and the rows show the account receipts. The matrix is organized as a single-entry bookkeeping system with row sums equal to column sums which imposes an accounting consistency. SAMs

[151]See Graham Pyatt and Erik Thorbecke, *Planning Techniques for a Better Future* (Geneva, Switzerland: International Labour Organization, 1976).

FIGURE 16. SIMPLIFIED INTERRELATIONSHIPS AMONG SAM ACCOUNTS.




Source: H. Khan and E. Thorbecke, *Macroeconomic Effects and Diffusion of Alternative Technologies within a Social Accounting Matrix Framework: The Case of Indonesia*, (Brookfield, VT: Gower Publishing Co., 1988) 19. © International Labour Organization by permission of Ashgate Publishing Limited.

are built upon national input-output tables derived from the United Nations System of National Accounts.

The level of disaggregation and detail of the production sector as provided in Leontief's interindustry transaction matrix is extended to the distribution of value-added to the factors of production and the household/companies consumption sectors in the SAM.[152]

[152]Haider Khan, *The Political Economy of Sanctions Against Apartheid* (Boulder, CO: Lynne Rienner Publishers, 1989), 27-28.

FIGURE 17. SIMPLIFIED SCHEMATIC SOCIAL ACCOUNTING MATRIX

| | | | Expenditures | | | | |
|---|---|---|---|---|---|---|---|
| | | | Factors | Households & Companies | Production Activities | Sum of Other Accounts | Totals |
| | | | 1 | 2 | 3 | 4 | 5 |
| Receipts | Factors | 1 | 0 | 0 | $T_{13}$ | $x_1$ | $y_1$ |
| | Households & Companies | 2 | $T_{21}$ | $T_{22}$ | 0 | $x_2$ | $y_2$ |
| | Production Activities | 3 | 0 | $T_{32}$ | $T_{33}$ | $x_3$ | $y_3$ |
| | Sum of Other Accounts | 4 | $x_1$ | $x_2$ | $x_3$ | $x$ | $y$ |
| | Totals | 5 | $y_1$ | $y_2$ | $y_3$ | $y$ | |

Source: H. Khan and E. Thorbecke, *Macroeconomic Effects and Diffusion of Alternative Technologies within a Social Accounting Matrix Framework: The Case of Indonesia*, (Brookfield, VT: Gower Publishing Co., 1988) 23. © International Labour Organization by permission of Ashgate Publishing Limited.

SAMs are superior to input-output matrices because SAMs incorporate the household accounts which expands the understanding of the intersectoral linkages within an economy. SAMs show how changes in production affect household income distribution and the effects of household income distribution upon final demand. These extensions are significant because one can more fully comprehend how technology and government policies affect the production sector, and in turn how the production sector affects the entire economy, especially the employment and household income distribution effects.

B. Brazil's Social Accounting Matrix

The starting point of the SAM-Tech that was constructed to explore Brazil's alternative fuel program and comparative technologies was a 39x39 1985 SAM built by Drs. M.J. Fernandes Willumsen and Robert Cruz at the Economics Department of Florida International University (see Appendix 1). It is based on the 1975 Brazilian 53x53 SAM built by Dr. M.J. Fernandes Willumsen (Ph.D. dissertation, Cornell University, 1984). In keeping with the characteristics of a SAM, it is a square table consisting of an equal number of rows and columns (39x39). By convention column accounts show expenditures and row accounts show receipts. The units of the SAM are millions of Brazilian Cr$. Secondary data was used exclusively.

There are eight factors of production: unskilled agricultural labor (F1), skilled agricultural labor (F2), agricultural managers/professionals (F3), agricultural capital (F4), unskilled non-agriculture labor (F5), skilled non-agriculture labor (F6), non-agriculture managers/professionals (F7), and non-agriculture capital (F8).

Nine household accounts are classified: rural capitalists (HH1), rural small producers (HH2), rural workers/tenant farmers (HH3), rural managers/professionals (HH4), urban capitalists (HH5), urban managers/professionals (HH6), urban small producers (HH7), urban organized workers (HH8), and urban non-organized workers (HH9). This stratification system takes into account social heterogeneity, which is crucially important for policy makers. Including other aspects of stratification besides income, this system minimizes the problems related to the assumption that poverty is only the lack of money and that inequality is primarily a problem of income distribution. Furthermore, this schema - unlike income groupings - enables the policy maker to identify the constituencies of policies and consequently elaborate more effective ones. These household description are modified and taken from Willumsen.[153]

The urban and rural capitalist households (HH1 and HH5) includes very rich people whose incomes are exclusively derived from return on assets. The capitalists do not participate directly in the production process. This household class is characterized principally by the ownership of the means of production and the control over investment decisions. Their power may spread through the system by affecting public opinion and also by political participation. Capitalists are often connected with large national and multinational corporations. This household class exercises strong influence on the economy and society, since most of the employment and investment opportunities depend on their decisions. In terms of income and life-style, the urban and rural capitalists are on the top of the stratification scheme in society.

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[153]M.J.F. Willumsen, "The Social Accounting Framework as a Tool for Policy

The next two household classes are the urban managers and professionals and the rural managers and professionals (HH4 and HH6). The members of these households are represented by the managerial class which has arisen with the development of bureaucracy in Brazil. It is comprised of propertied classes and wage-income classes and includes university or equivalently trained professionals such as lawyers, physicians, dentists, and all the very highly skilled managers.

The main distinction between this managerial and professional class and the capitalist class is the way they are involved in the production sector. Like the capitalists, the managers and professional households are likely to be conscious about the role they play in society, and the majority of them tend to belong to professional associations and to syndicates. Actually, this household is closer to the capitalist class than to the small producer class in terms of life-style.

The urban small producers and rural small producers households (HH2 and HH7) are made up of people with sufficient vocational skills to maintain a comfortable and secure lifestyle. It includes small employers who are directly involved in the production process. The main characteristic of this household is the medium level of education and skills of its members together with their freedom to be either employers, or self-employed. Moreover, the jobs they perform are not

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Analysis", 91-98.

routinized. Education is the distinguishing characteristic between the managers and professionals class and the small producers class.

The small producers class is comprised of many skilled occupations such as technicians, mechanics, blacksmiths, craftsmen, and other skilled professionals as well as insurance salesmen, real estate agents, and other sales categories which are better paid and which require higher skills than retail sales. Proprietors of small businesses, like owners of bars, groceries, cleaning establishments, and so on belong to the small producer household class.

The urban organized workers household class (HH8) includes semi-skilled people and some skilled ones with only a medium-level of education. The main characteristic of this household class is the existence of an employment contract to perform manual and clerical jobs. These jobs are highly routine, are closely supervised, and give little prestige (in terms of life-style) in society. These households include factory workers, clerks, retail salespeople, and those who perform administrative tasks; most belong to employees' associations and labor unions. They earn enough to maintain a reasonably comfortable life-style.

The rural workers and tenant farmers household class (HH3) is comprised of poor and low skilled and some unskilled salaried agricultural employees, such as laborers, low-paid operatives and service workers. Very often they work for small farms, and a reasonable proportion of those employees constitute, together with the poor self-employed and family workers, the informal sector of the economy. This household class lacks social organization to defend their interests. It is more difficult for them to recognize common interests and act as a social entity because members share the same social position and have a relatively low level of education. Consequently, they have neither labor unions nor any kind of association that could take a collective action to defend their interests.

At the very bottom of the social hierarchy is the urban non-organized workers household class (HH9). It is formed of the urban poor and includes odd jobbers such as shoe shiners, car cleaners, domestic workers, and all types of repair and maintenance workers. The absence of skill and education necessary for the work, and also the erratic character of the jobs, are the defining characteristics of this household. Thus, workers in this stratum have little or no participation in the regular labor force; they constitute the core of the informal sector of the Brazilian economy. Members of this household are discriminated against in the sense that they have much fewer opportunities, and have no secure status at all.

There are sixteen production activities accounts: export agriculture (A101), traditional agriculture (A102), livestock (A103), mineral extraction (A104), non-mineral extraction (A105), durable consumer goods (A106), non-durable consumer goods (A107), intermediate goods (A108), capital goods (A109), energy (A110), civil construction (A111), financial/commercial services (A112), commerce (A113), transportation and communication (A114), public services (A115), and private services (A116).

There are six additional accounts: one government account (G), one indirect tax account (T), one subsidies account (S), one domestic capital account (K), one rest of the world current account (ROW-C), and one rest of the world capital account (ROW-K).

C. Derivation of SAM-TECH

Two changes were made to Brazil's SAM in order to test the research hypotheses. First, the energy sector was disaggregated into 12 sub-sectors. Then carbon dioxide ($CO_2$) pollution coefficients were computed and a $CO_2$ sector was added. This then completed the development of a 51x51 SAM, now called SAM-Tech to denote some of the changes based technology. Figure 18 represents the 1985 SAM-Tech for Brazil (see Appendix 2).

1. Disaggregation of Energy Sector

The first step was to disaggregate the energy sector (A110) into 12 sub-sectors using data from Brazil's Energy Balances found in the 1991 Statistical Yearbook.[154] Initially, the energy sector was disaggregated into 11 sectors: coal/coke (E1), bagasse (E2), kerosene (E3), diesel oil/fuel oil/naphtha (E4), gasoline

[154] Fundacao Instituto Brasileiro de Geografia e Estatistica (IBGE), *Anuario*

FIGURE 18. BRAZILIAN SAM-TECH, 1985

| | | Expenditures | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Factors | Households | Activities | Energy | Carbon Dioxide | Gov't | Indirect Taxes | Subsidies | Domestic Capital | Rest of the World Current | Rest of the World Capital | Total |
| Receipts | Factors | | | | | | | | | | | | |
| | Households | | | | | | | | | | | | |
| | Activities | | | | | | | | | | | | |
| | Energy | | | | | | | | | | | | |
| | Carbon Dioxide | | | | | | | | | | | | |
| | Government | | | | | | | | | | | | |
| | Indirect Taxes | | | | | | | | | | | | |
| | Subsidies | | | | | | | | | | | | |
| | Domestic Capital | | | | | | | | | | | | |
| | Rest of world Current | | | | | | | | | | | | |
| | Rest of world Capital | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | |

(E5), ethanol (E6, E7), liquefied petroleum gas /natural gas/city gas (E8), electricity (E9), fuelwood (E10), charcoal (E11), and other (E12) according to Brazil's 1985 Energy Balance (IBGE, 1986). Later, the ethanol sector was disaggregated on the basis of technology: modern or traditional technology. This data was based on National Executive Commission of Alcohol and Pereira.[155]

*Estatistico do Brasil 1991* (Rio de Janeiro: IBGE, 1991) 635-649.

[155]CENAL, *The National Alcohol Program*, 8-12.

Then the monetary values for the energy sector (E1-E12) were derived by dividing the energy sub-sector (which were in million of tons of oil equivalent) by the total energy (also in million of tons of oil equivalent) and multiplying it by the monetary value of the final consumption energy sector in the SAM. This became the 1985 final consumption energy sector in millions of Brazilian Cr$.

Reconciliation of the SAM and SAM-Tech row and column accounts was based on a number of resources. The row accounts were derived by reckoning data from Brazil's Energy Balances found in the 1991 Statistical Yearbook,[156] Energy Balances of 40 Developing Countries,[157] and De Jannuzzi.[158] The row accounts were made consistent with the 1985 SAM with the exception of the export and traditional agriculture sectors. The SAM's agriculture energy consumption was significantly lower than indicated by the Energy Balances. Therefore, proportions were computed based on traditional and export agriculture energy consumption coefficients (mainly fuel oil consumption) as calculated by A.K.N. Reddy.[159] The column accounts were

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[156]Fundacao Instituto Brasileiro de Geografia e Estatistica (IBGE), *Anuario Estatistico do Brasil 1991*, 635-649.

[157]Commission of European Communities, *Energy Balances of 40 Developing Countries* (Brussels: Lavoisier, 1981) 106-108.

[158]Martino De Januzzi "Residential Energy Demand in Brazil by Income Class," 259.

[159]J. Goldemberg *et al.*, *Energy for a Sustainable World*, Chapter 1.3.10.

computed based on the 1980 input-output tables and discussions with Professor Maria Willumsen. The SAM-Tech energy sub-sectors were finalized.

2. Calculation of Carbon Dioxide Sector

A carbon dioxide ($CO_2$) pollution account was added to the SAM. The $CO_2$ coefficients were derived using data provided by La Rovere *et al.*[160] and discussions with Prof. Maria Willumsen.[161] La Rovere provided the quantity of $CO_2$ in terms of million tons of carbon (MtC) - generated by the following sectors: industry, residential, transportation, agriculture, energy, and public/commercial. Then these quantities were multiplied by a carbon dioxide cost coefficient.

The cost coefficient for $CO_2$ was taken from Intergovernmental Panel on Climate Change (IPCC)[162] documents and a conversation with J.C. Hourcade, convening author, of the IPCC Working Group III on the socioeconomic costs of greenhouse gas emissions. The marginal damage costs, that is the extra damage done by one extra tonne of carbon emitted is estimated to range from $5 to $125 per ton of carbon. The range reflects variations in models, discount rates, and other factors.

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[160] Emilio La Rovere, "Scenarios for Mitigating Greenhouse Gases Emissions and Promoting Sustainable Energy Development in Brazil," Interciencia 20, no.6 (November/December 1995): 343-347.

[161] Private correspondence, 1995.

[162] Intergovernmental Panel on Climate Change, "The Social Costs of Climate Change: Greenhouse Damage and the Benefits of Control," Working Group III

These cost estimates are based on simplistic and limited representations of a doubling of the pre-industrial $CO_2$ concentration or its equivalent for all greenhouse gases. They include both market and non-market impacts. This research used $5 in order to illustrate the most conservative environmental costs for 1985 and used the exchange rate of 6200 Cr$ per dollar for the $CO_2$ cost calculations. The $CO_2$ sector was now finalized.

The disaggregation of the energy sector and addition of a $CO_2$ sector completed the modifications to the original SAM and the SAM-Tech was constructed. The SAM-Tech is interesting because the energy sub-sectors include several biomass accounts and a pollution account. The next step is to establish a SAM-Tech model. Therefore, it is necessary to distinguish between a SAM framework and a SAM model.

## SECTION TWO: SAM-BASED MODEL

A SAM framework differs from modeling based on a SAM because the framework does not,

> postulate any causal mechanism regarding the determination of the actual quantities recorded in a SAM. The modeling approach does treat some accounts as being causally determined by others. In other words, some economic quantities are the result of interactions (often complex ones) between certain others. Specifically, we call those accounts in a SAM that are given to us (i.e., we do not claim to know how they are determined) by an economic process involving all the variables listed in the *exogenous* accounts. Those accounts that

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(January 1995 draft): 73.

list the variables thus determined within a particular model of the economy are *endogenous*. Thus, any change in government policy is exogenous. Given a model based on a SAM we can trace the effect of a policy on output, employment and incomes throughout the endogenous parts. These effects can be traced for all production activities, labor and capital income, household income and consumption, and so on.[163]

Different classes of SAM-based models exist. The SAM modeling of this research is based on the fixed price multipliers. It is a simple version of SAM-based general equilibrium models. Conclusions drawn from SAM-based modeling are subject to general limitations of the input-output methodology.

The fixed price SAM-based modeling has some theoretical and practical limitations. In theory, the modeling assumes that prices are fixed, technological coefficients between inputs and outputs are fixed, and full factor employment. Fixed prices suggests that changes in demand do not affect the equilibrium level of supply or demand of factors of production, i.e., there is no factor substitution or subsequent changes in equilibrium levels of demand. Fixed technological coefficients means that the technology in the year of the SAM does not change despite any transformation in the structure of production. These assumptions do not realistically explain final demand because they do not incorporate how changes in price affect the economic relationships, i.e., the substitution and income effects. In addition, SAMs assume excess capacity of production and labor variables which allow prices to remain

[163]Khan, *The Political Economy of Sanctions Against Apartheid*, 37.

constant and does not acknowledge existing supply constraints or other conditions which may cause prices to change. The fixed price and full employment assumptions become major limitations if there are large changes in exogenous demand and/or supply constraints which may cause relative prices to change. While fixed price SAM-based modeling cannot reveal the dynamic effects of supply constraints upon prices within the economy; it is problematic only if factor substitution and/or income effects cause relative prices to change.

From a practical standpoint, SAM-based modeling is limited by the quality of the data and assumptions made about the data. The SAM is a very data-intensive framework. Data come from a multiplicity of sources from various government departments which may not always collect or classify data consistently. Therefore, to have an accurate approximation of the true underlying relationships in the economy the SAM needs constant updating. To eliminate the effects of Brazil's inflation, the SAM was based on coefficients from 1980 data which was multiplied by data from the 1985 input-output tables. It is assumed that the structure of production did not change significantly between 1980 and 1985.

The results from the comparative static simulations, based on the fixed price SAM-based modeling, can be considered reasonably valid as long as relative price do not change. Changes in relative prices would have implications for factor substitution and adjustments in the equilibrium level of demand and supply. Therefore, SAM-based modeling is meaningful for short-term planning horizons. It can show the effects of different policies on various households and in fact on the entire economic system.

FIGURE 19. SCHEMATIC REPRESENTATION OF ENDOGENOUS AND EXOGENOUS SAM ACCOUNTS.

| | | | Expenditures | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Endogenous | | | | | Exogenous | | | | | | |
| | | | Factors | Households | Activities | Energy | Carbon Dioxide | Gov't | Indirect Taxes | Subsidies | Domestic Capital | Rest of the World | | Total |
| | | | | | | | | | | | | Current | Capital | |
| Receipts | Endogenous | Factors | | | | | | | | | | | | |
| | | Households | | | | | | | | | | | | |
| | | Activities | | | | | | | | | | | | |
| | | Energy | | | | | | | | | | | | |
| | | Carbon Dioxide | | | | | | | | | | | | |
| | Exogenous | Government | | | | | | | | | | | | |
| | | Indirect Taxes | | | | | | | | | | | | |
| | | Subsidies | | | | | | | | | | | | |
| | | Domestic Capital | | | | | | | | | | | | |
| | | Rest of world: Current | | | | | | | | | | | | |
| | | Rest of world: Capital | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | |

Figure 19 presents the SAM-TECH-based model for Brazil. In the Brazilian SAM-TECH model there are forty-five endogenous accounts: eight factors of production, nine institutions (household) accounts, and twenty-seven production activities. Six accounts are exogenous: government, domestic capital account, subsidies, net indirect taxes account, and two rest of the world accounts. Therefore, one can see how a change in an exogenous account affects the endogenous accounts. This transaction table provides the basis for understanding how changes in expenditure and receipts affect the endogenous and exogenous accounts via multiplier analysis.

A. Multiplier Analysis

An understanding of which accounts are endogenous and exogenous is important because the multiplier analysis of the SAM model methodology shows how a change in an exogenous account affects the endogenous account. The accounting multiplier and the fixed price multiplier reveal how a change in government, domestic capital formation, taxes, subsidies, and trade policies could affect production sectors, factors of production, and households. The employment multiplier is also calculated to show how changes in the exogenous accounts affect employment in the production activities.

1. Accounting Multiplier

Looking at Figure 20 which represents a SAM, we see that:

$$y = n + x \qquad (1)$$

$$y = l + t \qquad (2)$$

Now, if we divide the entries in the matrix $T_{nn}$ by the corresponding total income (i.e., $y_n$) we can define a corresponding matrix of average expenditure propensities.[164] This is matrix $A_n$.[164]

From $A_n$ the endogenous total income ($y_n$) in the transaction matrix is given:

$$y_n = A_n y_n + x \qquad (3)$$

FIGURE 20. SCHEMATIC REPRESENTATION OF ENDOGENOUS AND EXOGENOUS SAM ACCOUNTS.

| | | Expenditures | | | | Totals |
|---|---|---|---|---|---|---|
| | | Endogenous | Sum | Exogenous | Sum | |
| Receipts | Endogenous | $T_{nn}$ | n | $T_{nx}$ | x | $y_n$ |
| | Exogenous | $T_{xn}$ (Leakages) | l | $T_{xx}$ (Residual Balances) | t | $y_x$ |
| | | $y_n'$ | | $y_x'$ | | |

Source: H. Khan, *The Political Economy of Sanctions Against Apartheid.* © (Boulder, CO: Lynne Rienner Publishers, 1989) 56. Reprinted with permission.

This states the row sums of the endogenous accounts can be obtained by multiplying the average expenditures propensities for each row of endogenous accounts by the level of income recorded in each column and adding exogenous income x. This can now be expressed as: $y_n = (I - A_n)^{-1} x = M_a x$

$$y_n = M_a x \qquad (4)$$

164 Ibid., 57.

This is the accounting multiplier matrix (see Appendix 3). Now endogenous incomes can be derived by multiplying injection x by a multiplier matrix. The accounting multiplier has two limitations. One, it shows only the results of the change and not the causes of the change, which is due to the static nature of SAMs. Second, it assumes unitary expenditures elasticities. This assumption predicts that consumers purchasing behavior change by the exact change in their income, that is their expenditures on different commodities increases or decreases by exactly the same proportional change (increase or decrease) in their income.[165] Intuitively this is unrealistic. In order to compensate for this limitation, FPMs specify a matrix of marginal expenditure (income) elasticities. This provides a greater approximation of the true household consumption pattern and how different policies affect household income and consequent purchasing behavior. Hence, given the matrix of average expenditures and the corresponding expenditure elasticities of demand, the corresponding marginal expenditure propensities are easily computed.

This research uses the following matrix of marginal propensities, $C_n$

$$C_n = \begin{bmatrix} 0 & 0 & C_{13}=A_{13} \\ C_{21}=A_{21} & C_{22}=A_{22} & 0 \\ 0 & C_{32} & C_{33}=A_{33} \end{bmatrix}$$

[165]Ibid., 58.

It is assumed that the ownership pattern of factors remains constant, as well as the pattern of interinstitutional transfers, and the technological coefficients for any given activity. In contrast, realistic income elasticities of demand are postulated for the different socioeconomic groups yielding matrix $C_{32}$.[166]

2. Fixed Price Multipliers

To compensate for the unitary expenditures elasticities limitation, a matrix of marginal expenditures propensities ($C_n$ below) is specified corresponding to the observed income and expenditure elasticities of the different households while maintaining fixed prices. From the changes in income ($dy_n$) resulting from changes in injections ($dx$) one obtains:[167]

$$\begin{aligned} dy_n &= C_n dy_n + dx \\ &= (I - C_n)^{-1}\, dx \\ &= M_c\, dx \qquad (5) \end{aligned}$$

$M_c$ is known as the fixed price multiplier. It allows any nonnegative income and expenditure elasticity to be reflected in $M_c$.

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[166]Khan and Thorbecke, *Macroeconomic Effects and Diffusion of Alternative Technologies within a Social Accounting Matrix Framework: The Case of Indonesia*, 37.

[167]F.G. Pyatt and J. Round, "Accounting and Fixed Price Multipliers in a SAM," *Economic Journal* 89 (1979): 861.

The calculation of the marginal expenditures propensities ($MEP_i$) is computed if the average expenditures propensities ($AEP_i$) and the income expenditure elasticity ($Ey_i$) are known.

$Ey_i = MEP_i - AEP_i$

$$MEP_i = Ey_i (AEP_i) \quad (6)$$

$$\Sigma MEP = 1 \quad (7)$$

so, given the $A_{32}$ matrix (average expenditures propensities) and the expenditure elasticities of demand, the MEP matrix $C_{32}$ is derived. Given equation (7) different saving, import, taxation propensities can be estimated for different groups within the economy in addition to the consumption propensities. In principle, the marginal expenditures propensities of the other four submatrices $C_n$ can be calculated with the same procedure.

a. Household Expenditure Elasticities

The household expenditures elasticities were obtained by taking the percentage change between 1985 and 1975 household expenditures by class and dividing by the percentage change between 1985 and 1975 household income by class. The data used was household data from the Brazil 1975 input-output tables and the 1985 Brazilian SAM. First, the 1975 household survey expenditure data had to be classified and aggregated according to the 1985 SAM activity accounts.

Willumsen[168] provided the data and classification. Then the elasticities were computed by taking the percentage change in household consumption between 1975 and 1985 and dividing it by the percentage change in household income between 1975 and 1985 (see Appendix 4).

b. Household Marginal Expenditures Propensities

The household marginal expenditure propensities were computed by taking the household elements of the matrix of average expenditures propensities and multiplying each element by the corresponding household elasticity. Some of the resulting marginal expenditure propensities were negative and several had very high values. In these instances the average expenditure propensity was used. The average expenditure propensities were used for the following sectors: non-durable consumer goods sector (A107), financial services sector (A112), transportation sector (A114), and the public services sector (A115).

c. Fixed Price Multiplier Matrix

The fixed price multiplier matrix was calculated by substituting the household average expenditures propensities with the marginal expenditures and subtracting out the final (exogenous) demand and calculating the Leontief inverse (see Appendix 5).

[168]Maria Willumsen, private communication, 1995.

The FPM now shows how changes in dualistic production sectors affect employment and factor income distribution via the submatrix $M_c$ i.e., $M_{13}$. The multiplier shows how household income distribution changes from changes in output of any production coefficients associated with the dualistic production activities. The marginal expenditures propensities for $C_{32}$ of the FPM matrix $M_c$ also show how the household expenditure patterns differ among the households.

3. Total Employment Multipliers

The total employment multipliers were calculated using Brazil's 1980 input-output tables. The 1980 input-output tables provided the employment by production activity and output. First, the output and employment totals for the production activities had to be reclassified according to the SAM-Tech. Then the employment coefficients were computed by taking the employment in a sector and dividing it by the total output of that sector. This then gave each sector's employment coefficient. The employment coefficients were then multiplied by elements of the Leontief inverse matrix, i.e., the fixed price multiplier matrix. The columns were summed to give the total employment multipliers for each sector (see Appendix 6).

B. Structural Path Analysis

Structural path analysis (SPA) is used to decompose the accounting multipliers or the fixed price multipliers to show the direct and indirect effects of changes in an economic sector *j* on any other sector of the entire economy. The SPA of this research decomposes the accounting multiplier matrix to demonstrate how economic interactions are transmitted throughout the economic system. This type of analysis is based on the work of Defourny and Thorbecke.[169]

Since the application of SPA is relatively new, a brief discussion of the fundamentals of this methodology follows.[170] The starting point is to equate the notion of expenditure to that of "influence." Figure 21 shows that each average expenditure propensity $a_{ji}$ (or, alternatively, marginal expenditure propensity $(_{ji})$ of an "arc" $(_{i,j})$ linking two poles of the structure and oriented in the direction of the expenditure is to be interpreted as the magnitude of the influence transmitted from pole $_i$ to pole $_j$.

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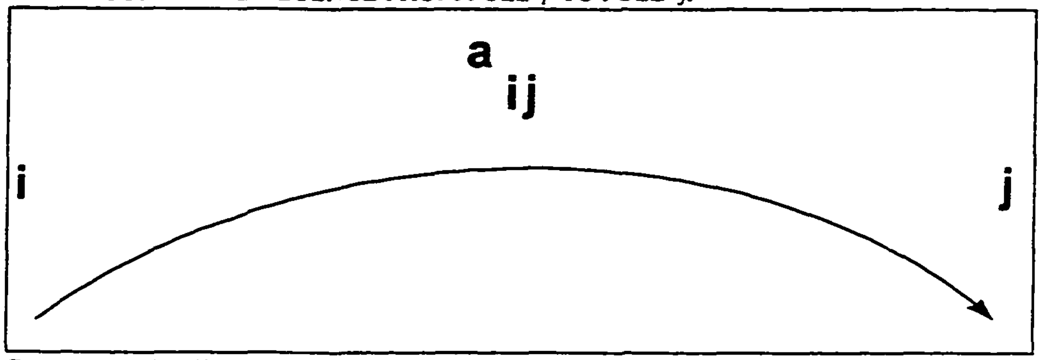
[169]Jacques Defourny and Erik Thorbecke, "Structural Path Analysis and Multiplier Decomposition Within a Social Accounting Matrix Framework," 111-136.

[170]This section follows Kahn and Thorbecke, *Macroeconomic Effects and Diffusion of Alternative Technologies*, 1988, 71-86. See also Defourny and Thorbecke, "Structural Path Analysis and Multiplier Decomposition Within a Social Accounting Matrix Framework," 111-136; Khan and Thorbecke, "Macroeconomic Effects of Technology Choice: Multiplier and Structural Path Analysis within a SAM Framework," *Journal of Policy Modeling* 11 (1989): 131-156.

FIGURE 21. INFLUENCE FROM POLE $i$ TO POLE $j$.



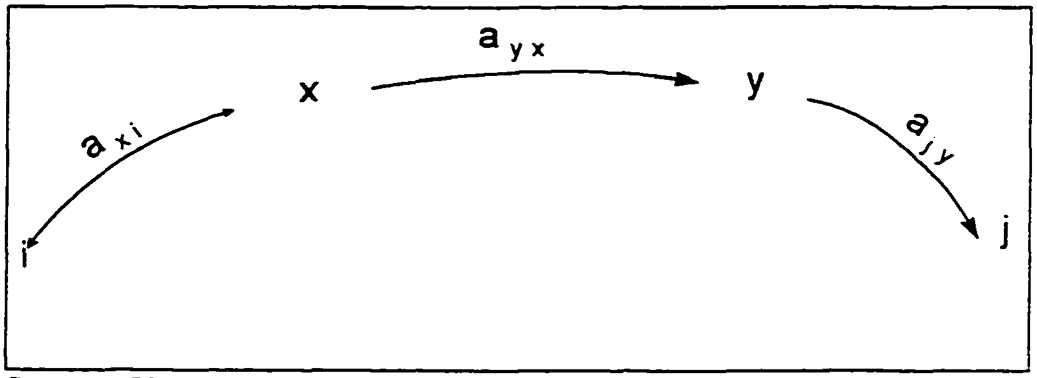

Source: H. Khan and E. Thorbecke, *Macroeconomic Effects and Diffusion of Alternative Technologies within a Social Accounting Matrix Framework: The Case of Indonesia.* (Brookfield, VT: Gower Publishing Co., 1988) 71. © International Labour Organization by permission of Ashgate Publishing Limited.

The average expenditure propensity $a_{ji}$ (or alternatively, the marginal expenditure propensity $c_{ji}$) reflects the "intensity" of arc (i,j). Hence, as will become clearer subsequently, an analysis based on accounting multipliers derived from the matrix of average expenditure propensities, $A_n$, of which $a_{ji}$ is an element presumes that influence is reflected by the latter. On the other hand, fixed price multipliers derived from the matrix of marginal expenditure propensities, $c_n$, assumes that the intensity of the influence between any two poles is captured by the corresponding value of the marginal expenditure propensities.

1. Paths

An elementary path (i,x,y,j) is one which passes only one time through the same pole, see figure 22.

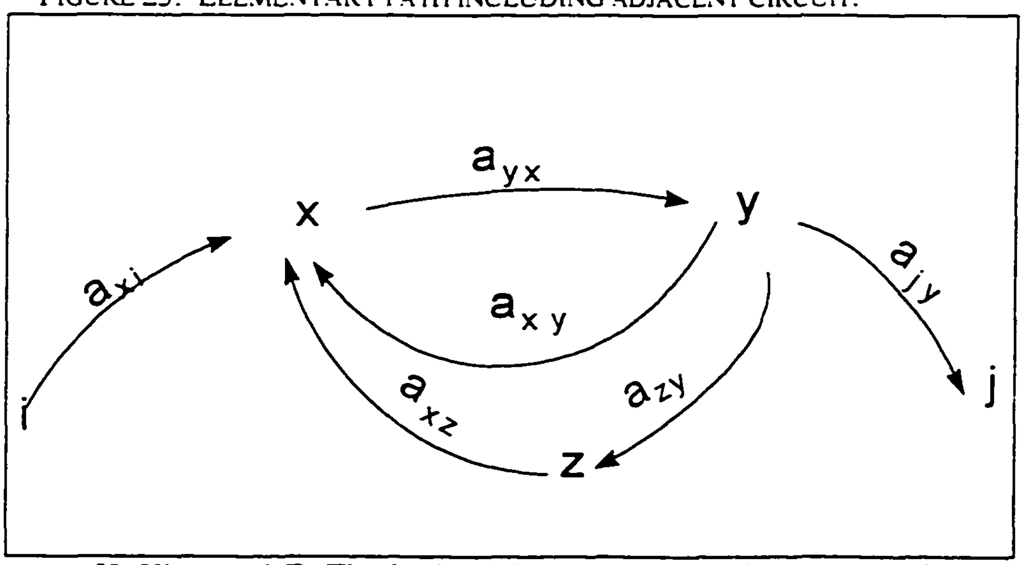
FIGURE 22. ELEMENTARY PATH.




Source: H. Khan and E. Thorbecke, Macroeconomic Effects and Diffusion of Alternative Technologies within a Social Accounting Matrix Framework: The Case of Indonesia. (Brookfield, VT: Gower Publishing Co., 1988). 72. © International Labour Organization by permission of Ashgate Publishing Limited.

A circuit path (i,x,y,z) is a path whose pole of origin (pole i) coincides with a pole of destination, see figure 23.

FIGURE 23. ELEMENTARY PATH INCLUDING ADJACENT CIRCUIT.




Source: H. Khan and E. Thorbecke, Macroeconomic Effects and Diffusion of Alternative Technologies within a Social Accounting Matrix Framework: The Case of Indonesia. (Brookfield: Gower Publishing Co., 1988) 73. © International Labour Organization by permission of Ashgate Publishing Limited.

The concept of influence is distinguished quantitatively in three ways: direct influence, total influence, and global influence.

2.1 *Direct Influence* The direct influence of i on j transmitted through an elementary path is the change in income (or production) of j induced by a unitary change in i, the income (or the production) of all other poles except those along the selected elementary path remaining constant. In other words, the direct influence indicates the extent to which an exogenous increase in one sector j initially affects other sectors directly linked to sector j. The direct influence can be measured along an arc or an elementary path.

A. Direct Influence of i on j along arc (i,j)

$$I^D (I \rightarrow j) = a_{ji} \qquad (8)$$

where $a_{ji}$ is the (j,i) element of the matrix of average expenditure propensities $A_n$. Matrix $A_n$ can therefore be called the matrix of direct influence - when the direct influence is measured along *arc i,j*.

B. Direct Influence along Elementary Path (i,..j).

The direct influence transmitted from pole i to pole j along a given elementary path is equal to the product of the intensities of the arcs constituting the path. Thus,

$$I^D_{(i...j)} = a_{jn} \ldots a_{mi} \qquad (9)$$

For example, figure 22 represents a given elementary path, p = (i,x,y,j)

$$I^D (i \rightarrow j)_p = I^D (i,x,y,j) = a_{xi}{*}a_{yx}{*}a_{jy} \qquad (10)$$

*2.2 Total Influence* The total influence captures the direct influence transmitted along a given elementary path and the indirect effects induced by the circuits adjacent to the same path (which have one or more poles in common with path, p). The total influence captures the direct effects of an exogenous increase in the sectors that were initially affected by sector *j*, i.e., the secondary effects of the sectors directly linked to sector *j*. Figure 23 shows that between poles i and j the direct influence is the product of $a_{xi}{*}a_{yx}$ which is then transmitted back from y to x via the two loops yielding an effect $(a_{xi}a_{yx})\,(a_{xy} + a_{zy}\,a_{xz})$ which in turn has to be transmitted back from x to y. This process yields, a series of decreasing repercussion effects between x and y.

$$a_{xi}\,a_{yx}\,\{1+a_{yx}\,(a_{xy} + a_{zy}\,a_{xz}) + [a_{yx}\,(a_{xy} + a_{zy}\,a_{xz})]^2 + \ldots\} = a_{xi}\,a_{yx}\,[\,I - a_{yx}\,(a_{xy} + a_{zy}\,a_{xz})\,]^{-1}$$

To complete the transmission of influence along the elementary path, p, the above effects have to travel along the last arc *(y,j)* so that the above effects have to be multiplied by $a_{jy}$ to obtain the total influence along this path,

$$I^T (i \rightarrow j)_p = a_{xi}\,a_{yx}\,a_{jy}\,[I - a_{yx}\,(a_{xy} + a_{zy}\,a_{xz})]^{-1} \qquad (11)$$

The direct influence is represented by the first term on the right hand side of equation (11),

$I^D (i \rightarrow j)^p M_p$ (12)

$M_p$ captures the extent to which the direct influence along path p is amplified through the effects of adjacent feedback circuits and gives the total influence.

*2.3 Global Influence* The global influence does not follow a specific path in the transmission of influence as measured by direct and total influences. Rather, global influence from pole *i* to pole *j* simply measures the total effects on income or output from pole *j* consequent to an injection of one unit of income or output in pole *i*. The direct influence is linked to particular elementary path which is entirely isolated from the rest of the structure. The global influence captures the direct influence transmitted by all elementary path linking the two poles under consideration. In addition, the global influence cumulates all the induced and feedback effects resulting from the circuits. To summarize, the global influence captures all the direct and indirect effects of all sectors affected by an exogenous increase in sector *j*. Therefore, global influence is equal to the sum of the total influence of all elementary paths spanning pole *i* and pole *j*.

The global influence is captured by the reduced form of the SAM model derived previously:

$$dy_n = (I-a_n)^{-1}dx = M_a \, dx \quad (13)$$

Let $Ma_{ji}$ be the (j,i)th element of the matrix of accounting multipliers Ma then, it captures the full effects of an exogenous injection $dx_i$ on the endogenous variable $dy_j$. Hence,

$$I^G (i \rightarrow J) = Ma_{ji},$$

and matrix $Ma = (I - An)^{-1}$ can be called the matrix of global influences.

Therefore, the global influence linking any two poles can be decomposed into a series of total influences transmitted along each and all elementary paths spanning poles i and j.

$$I^G (i \rightarrow j) = Ma_{ji} = \quad I^T (i \rightarrow j)_p = \quad I^D( i \rightarrow j)_p M_p$$

Once the matrix of accounting multipliers is known, SPA, demonstrates how economic interactions are transmitted throughout the entire economic system. First, this research SPA equates average expenditure propensities to influence. Graphically this means that each average expenditure propensity, $a_{ji}$, of an arc $(i,j)$ linking two poles of the structure and oriented in the direction of the expenditure is to be interpreted as the magnitude of the influence transmitted from pole $i$ to pole $j$. SPA reveals how the economy is connected by decomposing the global influence into the direct and induced/feedback effects resulting from the existence of elementary path (a path which does not pass more than one time through the same pole) and circuit paths (paths for which the pole of origin coincides with the pole of destination).

The endogenous structure of the SAM means that an elementary path must always travel in the triangular direction as shown in figure 16. In this case an injection occurs in a production activity, (i.e., ethanol production), all elementary paths originating with that activity would affect, first, other production activities (through the induced demand for intermediate inputs represented by the I-O matrix $A_{33}$) and factor demand (through the distribution of value added among factors, (i.e., matrix $A_{13}$) before the influence is transmitted to institutions (in particular, the different household groups) through matrix $A_{21}$. Next, transfers among institutions would be captured through $A_{22}$ before the final link back to production activities (reflecting the consumption pattern of institutions, i.e., $A_{32}$) can take place.

## SECTION THREE: CONCLUSION

The SAM framework is a superior tool for social and economic planning because it is able to provide a detailed disaggregation of the economic activities of households. This is a significant contribution to economy-wide models which typically disaggregate in detail the production activities and factor requirements, but do not include detail on household economic activities.

The SAM framework summarizes the interrelationships among the structure of production, output; the distribution of value-added going to the factors of production generated by the production activities, employment; and the income distribution by socioeconomic groups, households; as well as the corresponding consumption and savings behavior of these socioeconomic groups.

The 51x51 SAM used in this research, named SAM-TECH, contains twelve energy sub-sectors including four biomass accounts and incorporates a pollution sector. The SAM-TECH has two different ethanol production technologies to capture each technology's employment, income distribution, and environmental effects. This study is the first that quantifies the income distribution effects of the ethanol industry and the second analysis which considers data between 1975 and 1985. The SAM-TECH model has forty-five endogenous accounts: eight factors of production, nine household accounts, twenty-seven production activities, and one pollution sector. Six accounts are exogenous: the government account, domestic capital account, net indirect taxes account, and two rest of the world accounts. This modeling shows how a change in an exogenous account affects the endogenous accounts. This transaction table provides the basis for understanding how changes in exogenous expenditures and receipts affect the endogenous accounts via multiplier analysis.

This research uses fixed price multipliers and structural path analysis to assess the macroeconomic impacts due to the development of Brazil's ethanol industry. FPM and SPA provide an efficient and comprehensive methodology to evaluate the research hypotheses. The strength of this methodology is its ability to capture the direct and indirect effects of changes in exogenous demand to factor, household, production activities expenditures and receipts. The major shortcoming of the SAM framework and modeling is that its a tool only for short-run planning. This limitation exists because of its static nature and fixed prices. The next chapter presents the research hypotheses and findings.

# CHAPTER SEVEN

# RESEARCH FINDINGS

The purpose of this research is to better understand the extent to which technology choice affects development, particularly poverty alleviation. While the past chapters have described Brazil's alternative fuel program in detail, the current chapter provides an empirical assessment of the ethanol industry and other economic sectors. Five hypotheses are tested which examine the direct and indirect effects of growth in several economic sectors on Brazil's socioeconomic, environmental, and energy development. The first part of the hypotheses compares the gasoline and ethanol sectors' effect on employment, income generation and distribution, energy intensity, and the environment. The second part of the hypotheses contrasts the employment, income, energy, and environmental effects of a labor-intensive technique and a capital-intensive technique used in the following production activities: agriculture (export agriculture sector and traditional agriculture sector), manufacturing (durable consumer goods sector and non-durable consumer goods sector), energy, and services (financial/commercial services sector, public services sector, and private services sector).

In this research technology choice is determined by labor coefficients for the manufacturing and service sectors which were calculated from the total employment multiplier matrix. The agriculture sectors were pre-classified; even though the export agriculture sector has a higher labor ratio, it was classified as the relatively capital intensive technology. The following production activities were identified as the labor-intensive technologies since they have relatively higher labor intensities: traditional agriculture, non-durable consumer goods, and private services. The production activities that are classified as capital-intensive technologies are: export agriculture, durable consumer goods, and financial/commercial services. The labor coefficient for the private services sector was the highest followed by the financial/services sector and the public services sector.

This empirical assessment will aid policy makers to grasp the ramifications of technology choice and effects of growth in different economic sectors on the country's overall development. The findings of this research will show which production sectors contribute most to poverty alleviation, energy intensity, and environmental goals. Finally, differences in the ability of various economic sectors to reduce poverty, promote renewable energy development, and reduce greenhouse gas emissions can be traced to a number of direct and indirect linkages within the economy.

HYPOTHESIS ONE: TECHNOLOGY CHOICE AND EMPLOYMENT

Comparing the employment effects of a labor-intensive technology with a capital-intensive technology may seem intuitively unnecessary because the labor-intensive technology by definition should have a higher employment coefficient. However this defining characteristic considers only the direct employment effects of a given economic sector. Does a labor-intensive technology always generate more employment than the comparable capital-intensive technology? The SAM-based modeling captures both the direct and indirect employment impacts. The objective of this hypothesis is to determine which technology generates the greatest total employment.

*It is hypothesized that the adoption of labor-intensive technologies provides greater total employment than capital-intensive technologies.* The first part of the hypothesis determines whether Brazil's ethanol sectors provide more employment than the gasoline sector. The second part of the hypothesis examines the employment effects of the agriculture, manufacturing, and service sectors.

This hypothesis is tested once the fixed price multiplier matrix $M_c$, i.e., $M_{33}$, and the physical labor input coefficients for the activities are known. The hypothesis is accepted if the employment multipliers for the labor-intensive technologies are greater than the employment multipliers for capital-intensive technologies. The hypothesis is rejected if the employment effects of the ethanol, traditional agriculture, durable consumer goods, and private services sectors are less than the gasoline, export agriculture, consumer non-durable goods, and financial/commercial services sectors.

A.1.1 Employment and the Ethanol and Gasoline Sectors

Table 24 presents the employment multipliers for the ethanol and gasoline sectors. It shows that the employment multipliers for the ethanol sector are higher than the multipliers for the gasoline sector. The ethanol employment multipliers are 14.49 for the modern ethanol sector, 14.38 for the traditional ethanol sector, and 11.01 for the gasoline sector. The ethanol employment multipliers are not significantly different. Interestingly, even though the direct employment effects of the traditional ethanol sector are about three times greater than the modern ethanol sector, the total employment which includes the direct and indirect employment of the modern ethanol sector are larger than the traditional ethanol sector. The indirect linkages of the modern ethanol sector particularly to the traditional agriculture sector is the source of employment differences. The result is that the modern ethanol sector employs slightly more people than the traditional ethanol sector.

Employment in the ethanol (renewable) sector is nearly three times greater than the gasoline (non-renewable) sector. Further analysis of the employment multiplier matrix shows that the major source of employment for the ethanol sectors is the traditional agriculture sector.

Table 24. Gasoline and ethanol sectors employment multipliers.

| | Gasoline | Ethanol-M | Ethanol-T |
|---|---|---|---|
| Export Agriculture | 1.55 | 1.20 | 1.21 |
| Trad. Agriculture | 1.40 | 6.73 | 6.34 |
| Livestock | 0.39 | 0.39 | 0.40 |
| Mineral Extraction | 0.02 | 0.02 | 0.02 |
| Non-Mineral Ext. | 0.63 | 0.11 | 0.11 |
| Durable Goods | 0.24 | 0.19 | 0.19 |
| Non-Durable Goods | 0.59 | 0.49 | 0.50 |
| Intermediate Goods | 0.57 | 0.48 | 0.48 |
| Capital Goods | 0.14 | 0.11 | 0.11 |
| Coal | 0.02 | 0.01 | 0.01 |
| Bagasse | 0.01 | 0.01 | 0.01 |
| Kerosene | 0.00 | 0.00 | 0.00 |
| Oil | 0.01 | 0.01 | 0.01 |
| Gasoline | 0.06 | 0.00 | 0.00 |
| Ethanol-M | 0.00 | 0.10 | 0.00 |
| Ethanol-T | 0.00 | 0.00 | 0.28 |
| Gas | 0.01 | 0.01 | 0.01 |
| Electricity | 0.08 | 0.06 | 0.06 |
| Fuelwood | 0.67 | 0.54 | 0.54 |
| Veg. Charcoal | 0.34 | 0.26 | 0.26 |
| Other | 0.01 | 0.00 | 0.00 |
| Civil Construction | 0.04 | 0.05 | 0.05 |
| Fin./Com. Services | 0.55 | 0.50 | 0.52 |
| Commerce | 0.38 | 0.34 | 0.37 |
| Transport/Comm. | 1.94 | 1.53 | 1.55 |
| Public Services | 0.06 | 0.05 | 0.05 |
| Private Services | 1.33 | 1.29 | 1.30 |
| SUM | 11.01 | 14.49 | 14.38 |

Source: Employment Multiplier Matrix.

### A.1.2 Employment and Production Activities

Table 25 provides the employment multipliers for the agriculture, manufacturing, and service sectors. An exogenous increase in the export agriculture sector results in an additional 19.20 people being employed within the entire economy and direct employment of 9.67 people in the export agriculture sector; the traditional agriculture sector employs an additional 16.43 people within the entire economy and 9.52 people in the traditional agriculture sector. The employment multiplier for the non-durable consumer goods sector is 12.87 and 12.03 for the durable consumer goods sector. Analysis of the service industry shows that the private service sector has the highest employment coefficient, 12.89, followed by the public services sector, 10.97, and the financial/commercial service sector, 8.48. Analyzing these sectors indicates that employment generation is the greatest for the agriculture sector, followed by the service sector, and the manufacturing sector.

The relatively more labor-intensive techniques of the manufacturing and service sectors have greater employment than the comparative capital-intensive techniques. Contrary to expectations, the employment multipliers of the relatively capital-intensive technology of the agriculture sector is greater than the labor-intensive technique. Examination of the employment multiplier matrix shows that the direct and indirect employment effects are greater for the export agriculture sector than the traditional agriculture sector. The export agriculture sector has more linkages particularly to the traditional agriculture sector and the transportation/communication sector than the traditional agriculture sector.

Table 25. Select production activities employment multipliers.

| | Ag-Export K | Ag-Trad L | Cons-Dur K | Con-ND L | Financial K | Public K | Private L |
|---|---|---|---|---|---|---|---|
| Export Agriculture | 9.67 | 9.52 | 1.73 | 1.92 | 0.82 | 1.10 | 1.09 |
| Traditional Agriculture | 1.55 | 0.44 | 1.48 | 2.01 | 0.81 | 1.18 | 1.17 |
| Livestock | 0.45 | 0.17 | 0.40 | 0.87 | 0.24 | 0.34 | 0.38 |
| Mineral Extraction | 0.02 | 0.04 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| Non-Mineral Extraction | 0.16 | 0.12 | 0.15 | 0.15 | 0.08 | 0.12 | 0.10 |
| Durable Consumer Goods | 0.26 | 0.21 | 1.17 | 0.24 | 0.14 | 0.18 | 0.17 |
| Non-Durable Cons. Goods | 0.62 | 0.51 | 0.60 | 1.38 | 0.37 | 0.51 | 0.56 |
| Intermediate Goods | 0.63 | 0.52 | 0.66 | 0.64 | 0.34 | 0.44 | 0.47 |
| Capital Goods | 0.13 | 0.11 | 0.19 | 0.13 | 0.08 | 0.11 | 0.15 |
| Coal (Coal Steam & Coke) | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| Bagasse | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Kerosene | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oil (diesel, fuel, naphtha) | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Gasoline | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ethanol-M | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ethanol-T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Gas (LPG,city gas, natural gas) | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 |
| Electricity | 0.09 | 0.07 | 0.09 | 0.08 | 0.04 | 0.07 | 0.06 |
| Fuelwood | 0.77 | 0.60 | 0.71 | 0.71 | 0.35 | 0.47 | 0.44 |
| Veg. Charcoal | 0.37 | 0.28 | 0.36 | 0.34 | 0.19 | 0.25 | 0.23 |
| Other | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Civil Construction | 0.04 | 0.03 | 0.04 | 0.04 | 0.10 | 0.06 | 0.04 |
| Financial/Commercial Services | 0.51 | 0.48 | 0.55 | 0.54 | 2.15 | 0.80 | 0.53 |
| Commerce | 0.35 | 0.32 | 0.39 | 0.38 | 0.33 | 0.44 | 0.36 |
| Transportation/Communication | 2.13 | 1.64 | 2.04 | 1.97 | 1.10 | 1.46 | 1.33 |
| Public Services | 0.06 | 0.05 | 0.06 | 0.06 | 0.04 | 1.84 | 0.05 |
| Private Services | 1.31 | 1.29 | 1.33 | 1.34 | 1.27 | 1.55 | 5.71 |
| Sum | 19.20 | 16.43 | 12.03 | 12.87 | 8.48 | 10.97 | 12.89 |

Source: Employment Multiplier Matrix.

Hypothesis one is not accepted because total employment associated with all the labor-intensive technologies is not always greater than the corresponding capital-intensive technologies. The ethanol sectors provide more employment than the gasoline sectors. While the modern ethanol sector generates slightly more employment than the traditional ethanol sector, the difference is not significant.

In two of three economic sectors studied, the labor-intensive technologies generated more total employment than the capital-intensive technologies. The labor-intensive technologies of the consumer non-durable goods sector and the private services sector provide greater total employment than the capital intensive technologies of the durable goods sector and the service sectors (public and financial/commercial services sectors). There is one exception: the export agriculture sector generates more total employment than the traditional agriculture sector.

HYPOTHESIS TWO: TECHNOLOGY CHOICE AND FACTOR INCOME

The choice of technology significantly affects the income to the factors of production. Labor and capital income are the basis of household income. Therefore, it is important to understand how different sectors affect labor and capital income, and ultimately, how growth in different sectors affects poverty. The labor-intensive technology by definition has a higher labor to capital ratio than the capital-intensive technology. Presumably, labor income should be higher with the labor-intensive technology.

It is hypothesized that the adoption of labor-intensive technologies generates greater total labor and capital income than capital-intensive technologies. The first part of the hypothesis ascertains whether Brazil's ethanol industry provides more factor income than the gasoline sector. The second part of the hypothesis examines the factor income effects of the agriculture, manufacturing, and service sectors. Then each sector is analyzed to determine its impact on the labor income of unskilled agricultural and non-agricultural workers.

The hypothesis is tested within the submatrix of the fixed price multiplier matrix $M_{13}$. Adding the fixed price multipliers for all labor and capital factors for the ethanol, gasoline, agriculture, manufacturing, and service sectors gives the factor income accruing to each sector. The data show which sectors provide greater labor and capital income.

Hypothesis two is accepted if total labor and capital income for the ethanol sectors, traditional agriculture sector, non-durable consumer goods sector, and private services sector are greater than those for the gasoline sector, export agriculture sector, durable consumer goods sector, and the public services sector as well as the financial services sector. The hypothesis is rejected if the factor income of the labor-intensive technologies are less than the capital-intensive technologies.

B.1.1 Factor Income and the Gasoline and Ethanol Sectors

Table 26 presents the factor income from the gasoline and ethanol sectors as a result of an additional 1000 Cr$ increase in exogenous demand. Each number is rounded to make it easier to interpret. An additional 1000 Cr$ of exogenous demand will lead to additional labor and capital factor incomes for the gasoline sector of

(1562 Cr$); whereas, the labor and capital factor incomes for both the modern and traditional ethanol sectors will increase by (3326 Cr$) (1639 Cr$+1687 Cr$). Total labor income is (453 Cr$) for the modern ethanol technology, (522 Cr$) for the traditional ethanol technology, and (493 Cr$) for the gasoline sector. The ethanol sectors generate more total labor income than the gasoline sector. Furthermore, the traditional ethanol production technology provides greater labor income (522 Cr$) than the modern ethanol production technology (453 Cr$). While the capital income of the ethanol sectors (1185 Cr$ + 1165 Cr$ = 2350 Cr$) is more than the capital income of the gasoline sector (1069 Cr$); the modern ethanol sector generates more capital income (1185 Cr$) than the traditional ethanol sector (1165 Cr$).

Table 26. Gasoline and ethanol sector factor income (Cr$)

| | Gasoline | Ethanol-M | Ethanol-T |
|---|---|---|---|
| 1000 | E110-5 | E110-6 | E110-7 |
| Unskilled Ag. Labor | 6 | 12 | 12 |
| Skilled Ag. Labor | 19 | 49 | 47 |
| Mgrs/Prof. Ag Labor | 1 | 5 | 4 |
| Ag.Capital | 129 | 403 | 383 |
| Unskilled Non Ag. Labor | 173 | 148 | 202 |
| Skilled Non-Ag. Labor | 220 | 167 | 196 |
| Mgrs/Prof. Non-Ag Labor | 75 | 73 | 62 |
| Non-Ag. Capital | 940 | 782 | 782 |
| Total labor/capital income | 1562 | 1639 | 1687 |
| Sum of labor income | 493 | 453 | 522 |
| Sum of capital income | 1069 | 1185 | 1165 |

Source: Fixed Price Multiplier Matrix

The finding of this hypothesis shows that ethanol's labor-intensive technology is superior to ethanol's capital-intensive technology for generating total labor income; however, the modern ethanol sector generates more capital income than the traditional ethanol sector.

B.1.2. Structural Path Analysis of Factor Income and the Ethanol and Gasoline Sectors

There is one caveat to all the structural path analyses of this research. The computer program that was utilized permitted a decomposition of the accounting multiplier only and not the fixed price multiplier. The result is that the numbers do not exactly correspond to the fixed price multiplier matrix and in some cases overestimates and in some cases underestimates the global effects. Generally, the accounting multiplier overestimates the global effects.

Structural path analysis (SPA) decomposes the accounting multipliers, also known as the global effect, into the direct effect and total effect. The direct effect indicates the extent to which an exogenous increase or decrease in sector *j* (also known as pole *j*) affects the immediate inputs into sector *j*. The total effect shows the direct effects due to a change in sector *j* and the indirect effects associated with the backward linkages of the sectors directly affected by a change in sector *j*. The global effect includes all the direct and indirect effects of all sectors affected by an exogenous increase or decrease in sector *j*

It is useful to understand how to read the SPA tables before a presentation of the results. Going from left to right on Table 27 one sees the following columns: path, global effect, direct effect, path multiplier, total effect, percentage of global effect, and percentage of cumulative effect. This research deals primarily with the global effect, direct effect, total effect, and percentage of global effect. The path indicates the pole of influence from a SAM column sector to a SAM row sector. That is, the poles of influence give the effect of a change in a column's sector expenditures on the receipts of a row sector. For example, the path [32,1] involves column sector 32, the modern ethanol sector, and row sector 1, unskilled agriculture labor. The global effect is the same as the accounting multiplier and is decomposed into the direct effect and total effect. The direct effect is the same as the average expenditures propensities and indicates the effect of an exogenous increase on the column sector expenditures on the row sector receipt. The total effect is the same as the indirect effects and includes the effects on other sectors. For example, the first path presented in Table 27 is path [32,19,1] - the poles are the modern ethanol sector (32) and the unskilled agriculture labor income (1); sector 19 is the traditional agriculture sector and is an intermediate pathway. A definition of the poles of the paths will be presented before the results.

Table 27 includes the following poles: 32-modern ethanol sector; 33 traditional ethanol sector; 1-unskilled agriculture labor income; 2-skilled agriculture labor income; 3-agriculture managerial income; 4-agriculture capital income; 5-unskilled non-agriculture labor income; 6-skilled non-agriculture labor income; 7-non-agriculture managerial income; 8-non-agriculture capital income.

Table 27. SPA - Effect of ethanol production on factor income.

| Path | | Global Effect | Direct Effect | Path Mult | Total Effect | % of Global | Cum % |
|---|---|---|---|---|---|---|---|
| 32, 19, 1 | | 0.013 | 0.007 | 1.226 | 0.008 | 64.6 | 64.6 |
| 33, 19, 1 | | 0.012 | 0.006 | 1.226 | 0.008 | 61.9 | 61.9 |
| 32, 19, 2 | | 0.051 | 0.031 | 1.234 | 0.038 | 74.5 | 74.5 |
| 33, 19, 2 | | 0.049 | 0.029 | 1.234 | 0.035 | 71.9 | 71.9 |
| 32, 19, 3 | | 0.005 | 0.004 | 1.221 | 0.004 | 91.8 | 91.8 |
| 33, 19, 3 | | 0.004 | 0.003 | 1.221 | 0.004 | 89.9 | 89.9 |
| 32, 19, 4 | | 0.416 | 0.282 | 1.256 | 0.354 | 85 | 85 |
| 33, 19, 4 | | 0.397 | 0.261 | 1.256 | 0.328 | 82.7 | 82.7 |
| 32, 5 | | 0.142 | 0.021 | 1.143 | 0.024 | 17.1 | 17.1 |
| 33, 5 | | 0.195 | 0.073 | 1.143 | 0.083 | 42.7 | 42.7 |
| 32, 6 | | 0.161 | 0.025 | 1.162 | 0.029 | 18.3 | 18.3 |
| 33, 6 | | 0.19 | 0.052 | 1.162 | 0.06 | 31.6 | 31.6 |
| 32, 7 | | 0.072 | 0.017 | 1.044 | 0.018 | 25.3 | 25.3 |
| 33, 7 | | 0.06 | 0.005 | 1.044 | 0.006 | 9.3 | 9.3 |
| 32, 8 | | 0.779 | 0.141 | 1.481 | 0.208 | 26.8 | 26.8 |
| 33, 8 | | 0.779 | 0.127 | 1.481 | 0.188 | 24.1 | 24.1 |

Table 27 presents the global influence of the modern and traditional ethanol sectors on factor incomes. For path [32,19,1] the global influence of the modern ethanol sector on unskilled agriculture workers income is (.013); that is, a one Cr$ increase in the modern ethanol sector will result in an increase in total income to unskilled agriculture workers of (.013 Cr$). The modern ethanol sector's global influence on skilled agriculture workers [path 32,19,2] is (.051 Cr$) and is (.005 Cr$)

on professional labor [path 32,19,3]. The global influence of traditional ethanol technology on unskilled agriculture workers [path 33,19,1] is (.012 Cr$), on skilled agriculture workers [path 33, 19,2] is (.049 Cr$), and on agriculture professionals is (.004 Cr$) [path 33,19,3]. Thus, the global influence of the modern ethanol sector is slightly greater than the traditional ethanol production sector's global influence on the income of unskilled agriculture workers. The global influence of the traditional ethanol sector is larger than the modern ethanol sector for two of three non-agriculture labor income groups. The global influence of the traditional ethanol sector on the income of unskilled non-agriculture workers [path 33,5] is (.195 Cr$); whereas, the global influence of the modern ethanol sector on the income of unskilled non-agriculture workers is (.142 Cr$) [path 32,5]. The global influence of the traditional ethanol sector on the income of non-agriculture skilled workers is (.190 Cr$) [path 33,6], while the global influence of the modern ethanol sector on the income of skilled non-agriculture workers is (.161 Cr$) [path 32,6]. Finally, the global influence of the modern ethanol sector on non-agriculture professionals is (.072 Cr$) [path 32,7], while the global influence of the traditional ethanol sector on non-agriculture professionals is (.06 Cr$) [path 33,7]. Coincidentally, both ethanol production technologies yield the same return to non-agricultural capital - (.779 Cr$).

The SAM-based methodology highlights a significant difference in the income received by both unskilled and skilled non-agriculture labor from the ethanol sectors due to technology choice. The labor income of unskilled and skilled non-agriculture workers increases significantly more with the traditional ethanol sector than the modern ethanol sector. This difference can be better understood by decomposing and diagramming the accounting multiplier. SPA is used to illustrate the effects of technology choice on the income of unskilled non-agriculture labor.

Figures 24 and 25 show the effect of ethanol production on unskilled non-agriculture labor income. The underlined numbers identifies differences between the two technologies. Comparing the two figures indicates that unskilled non-agriculture labor receives significantly more labor income from the traditional ethanol sector than from the modern ethanol sector. Figure 24 reveals that unskilled non-agriculture receives (73 Cr$) directly from the traditional ethanol technology and (21 Cr$)

FIGURE 24. INCOME EFFECTS OF TRADITIONAL ETHANOL SECTOR ON UNSKILLED NON-AGRICULTURE LABOR.

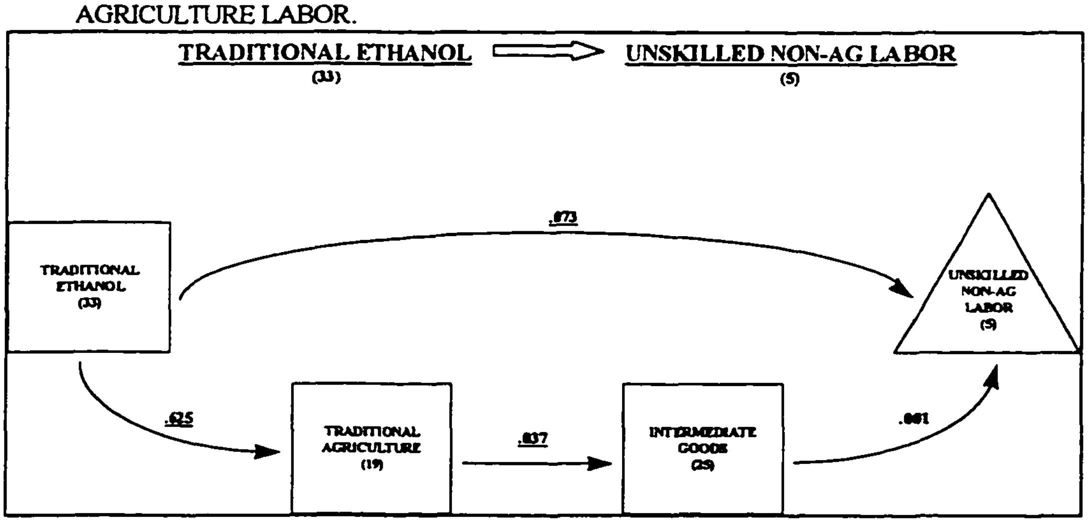
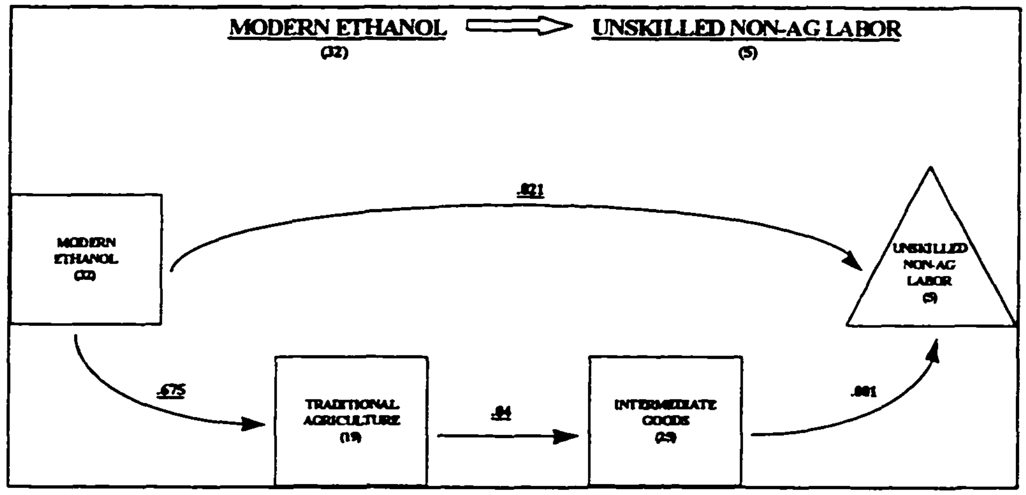


FIGURE 25. INCOME EFFECTS OF MODERN ETHANOL SECTOR ON UNSKILLED NON-AGRICULTURE LABOR.




directly from the modern ethanol technology (figure 25). Regional wages associated with the traditional technology are substantially higher than those of the modern ethanol sector; thus wages account for this difference. In addition, employment is more than three times greater in the northeast than in the center south. Higher wages and greater employment requirements of traditional ethanol distilleries result in labor costs which are significantly higher for the traditional ethanol distilleries than for the modern ethanol distilleries.

The policy implications of this analysis suggests that unskilled non-agriculture labor benefits significantly more from the traditional ethanol sector than the modern ethanol sector.

B1.3. Factor Income and Production Activities

Table 28 presents the labor and capital income associated with the agriculture, manufacturing, and service sectors. The traditional agriculture sector (1620 Cr$) produces more total factor income than the export agriculture sector (1502 Cr$). The traditional agriculture sector provides more total capital income (1202 Cr$) and less

Table 28. Production activities and factor income (Cr$).

| | Ag-Export | Ag-Trad | Cons-Dur | Con-ND | Financial | Public | Private |
|---|---|---|---|---|---|---|---|
| 1000 | K | L | K | L | K | K | L |
| Unskilled Ag. Labor | 12 | 16 | 6 | 10 | 3 | 5 | 5 |
| Skilled Ag. Labor | 33 | 66 | 20 | 33 | 11 | 16 | 16 |
| Mgrs/Prof. Ag Labor | 1 | 6 | 1 | 2 | 1 | 1 | 1 |
| Ag.Capital | 314 | 555 | 138 | 198 | 74 | 105 | 107 |
| Unskilled Non Ag. Labor | 151 | 129 | 180 | 167 | 155 | 374 | 224 |
| Skilled Non-Ag. Labor | 168 | 143 | 201 | 194 | 181 | 354 | 243 |
| Mgrs/Prof. Non-Ag Labor | 67 | 57 | 82 | 73 | 72 | 147 | 89 |
| Non-Ag. Capital | 755 | 647 | 867 | 868 | 1105 | 828 | 878 |
| | | | | | | | |
| Total Factor Income | 1502 | 1620 | 1493 | 1543 | 1603 | 1828 | 1563 |
| Total Capital Income | 1069 | 1202 | 1005 | 1066 | 1180 | 933 | 985 |
| Total Labor Income | 433 | 418 | 488 | 478 | 423 | 895 | 578 |
| | | | | | | | |
| Total Agriculture Labor Income | 46 | 88 | 27 | 44 | 15 | 21 | 22 |
| Total Non-Ag Labor Income | 387 | 329 | 462 | 433 | 408 | 874 | 556 |
| Ag. Unskilled Labor Income | 12 | 16 | 6 | 10 | 3 | 5 | 5 |
| Non-Ag. Unskilled Labor Income | 151 | 129 | 180 | 167 | 155 | 374 | 224 |

Source: Fixed Price Multiplier Matrix.

labor income (418 Cr$) than the export agriculture' sector capital income (1069 Cr$) and labor income (433 Cr$). Further inspection shows that the traditional agriculture sector raises more agriculture capital (555 Cr$) and agriculture labor income (88 Cr$) than the export agriculture sector's agriculture capital (314 Cr$) and labor (46 Cr$); while the export agriculture sector generates more non-agriculture labor income (387 Cr$) and non-agriculture capital income (755 Cr$) than the traditional agriculture sector's non-agriculture labor income (329 Cr$) and non-agriculture capital income (647 Cr$).

The non-durable consumer goods sector (1543 Cr$) generates more total factor income than the durable consumer goods sector (1493 Cr$). The non-durable consumer goods sector produces more capital income (1066 Cr$) and slightly less labor income (478 Cr$) than the consumer durable goods sector's capital income (1005 Cr$) and labor income (488 Cr$). Further examination shows that the non-durable consumer goods sector generates almost two times more agriculture labor income (44 Cr$) and unskilled agriculture labor income (10 Cr$) than the durable consumer goods sector's agriculture labor income (27 Cr$) and unskilled agriculture labor income (6 Cr$). The durable consumer goods sector raises more non-agriculture labor income (462 Cr$) and unskilled non-agriculture labor income (180 Cr$) than the non-durable consumer goods sector's non-agriculture labor income (433 Cr$) and unskilled non-agriculture labor income (167 Cr$).

The public services sector raises the most factor income (1828 Cr$) followed by the financial services sector (1603 Cr$), and private services sector (1563 Cr$). The public services sector generates the most labor income (895 Cr$) especially non-agriculture labor income (374 Cr$), while the financial services sector produces the most capital income (1180 Cr$), particularly non-agriculture capital (1105 Cr$). The private services sector generates the most agriculture labor income (22 Cr$).

The labor-intensive technologies generate the most agriculture labor income in each of the agriculture, manufacturing, and service sectors. The capital-intensive technologies produce the most non-agriculture labor income in each of the agriculture, manufacturing, and service sectors. The agriculture and manufacturing labor-intensive technologies generate more capital income than the capital-intensive technologies, which is due to the higher return to agriculture capital.

B1.4. SPA of Unskilled Labor Income and Production Activities

SPA was applied to examine the direct and indirect effects of an exogenous expenditure in production activity *i* on the income of factor *j*. In this case, the accounting multipliers for seven production activities (traditional and export agriculture, durable and non-durable consumer goods, and financial, private, and public services) were decomposed to demonstrate the production activities effects on the labor income of unskilled labor. This increase in income can be interpreted as an increase in income of factor *j* (unskilled workers) but as such does not identify in which sector the additional income is to occur. SPA gives the sector breakdown.

Table 29 includes the following poles: 18-export agriculture; 19 traditional agriculture; 23-durable consumer goods; 24-non-durable consumer goods; 40-financial/commerical services; 43-public services; 44-private services; 1-unskilled agriculture workers; 5-unorganized urban workers.

It can be seen from Table 29 that the labor income to unskilled agricultural workers increases more from the traditional agricultural sector (.016 Cr$) [path 19,1] than from the export agricultural sector (.012 Cr$) [path 18,1]. However, the labor income of unskilled non-agricultural workers increases more from export agriculture

Table 29. Effect of select production activities on unskilled workers labor income.

| Path | | Global Effect | Direct Effect | Path Mult | Total Effect | % of Global | Cum % |
|---|---|---|---|---|---|---|---|
| 18, 1 | | 0.012 | 0.005 | 1.234 | 0.007 | 54 | 54 |
| 19, 1 | | 0.016 | 0.01 | 1.225 | 0.012 | 73.3 | 73.3 |
| 18, 45, 24, 5 | | 0.145 | 0.002 | 5.196 | 0.009 | 6.3 | 6.3 |
| 19, 25, 5 | | 0.123 | 0.002 | 2.88 | 0.005 | 3.8 | 3.8 |
| 24, 20, 1 | | 0.011 | 0.003 | 1.962 | 0.006 | 56.4 | 56.4 |
| 23, 5 | | 0.174 | 0.02 | 1.539 | 0.031 | 17.9 | 17.9 |
| 23, 25, 5 | | | 0.002 | 3.129 | 0.007 | 3.8 | 21.7 |
| 23, 26, 5 | | | 0.004 | 1.939 | 0.008 | 4.7 | 26.4 |
| 23, 45, 24, 5 | | | 0.001 | 5.596 | 0.007 | 4.3 | 30.7 |
| 23, 45, 25, 5 | | | 0.002 | 7.088 | 0.016 | 9.5 | 40.1 |
| 23, 45, 42, 5 | | | 0.003 | 5.082 | 0.014 | 8.2 | 48.4 |
| 24, 5 | | 0.161 | 0.016 | 2.039 | 0.033 | 20.2 | 20.2 |
| 40, 5 | | 0.149 | 0.029 | 2.413 | 0.071 | 47.4 | 47.4 |
| 43, 5 | | 0.368 | 0.228 | 1.185 | 0.27 | 73.3 | 73.3 |
| 44, 5 | | 0.219 | 0.095 | 1.323 | 0.125 | 57.3 | 57.3 |

(.145 Cr$) [path 18,45,24, 5] than from traditional agriculture (.123 Cr$) [path 19,25,5]. Within manufacturing sectors being compared, only the non-durable goods sector generates labor income to unskilled agriculture workers (.011 Cr$) [path 24,20,1]. However, the durable goods sector creates more labor income to unskilled non-agriculture workers (.174 Cr$) [path 23,5] than the non-durable consumer goods sector (.161 Cr$) [path 24,5]. Unskilled non-agriculture workers receive the most labor income from the public services sector (.368 Cr$) [path 43,5], followed by the private services sector (.219 Cr$) [path 44,5] and the financial/commercial services sector (.149 Cr$) [path 40,5]. Further analysis shows that the manufacturing and service sectors provide an example where the indirect effects on labor income are larger than the direct effects. The durable consumer goods sector shows that the sum of proportional indirect effects for unskilled non-agricultural workers transmitted indirectly via the demand for intermediate and capital goods as well as non-agricultural goods including paths [23, 25, 5] through paths [23, 45, 42, 5] (3.8+4.7+4.3+9.5+8.2=30.5%) was greater than the proportional direct effects of the consumer durable goods sector 17.9% [path 23,5]. The service sectors (poles 40,43,44) are not tied to agriculture and do not employ a significant number of agricultural workers. Interestingly, the global influence of an exogenous increase in the public service sector on the income of unskilled non-agriculture workers is the largest (.368 Cr$) [path 43, 5], followed by the global influence of the private services sector on unskilled non-agriculture income (.219 Cr$) [path 44,5], and the global influence of financial /commercial services sector on unskilled non-agriculture worker income is (.149 Cr$) [path 40,5]. This finding suggests that indirect effects are sometimes significant and deserve further examination, especially if the global influence of two production activities is approximately the same.

Hypothesis two is not accepted because not all labor-intensive technologies provide more total labor and capital income than the comparative capital-intensive technologies. While ethanol's labor-intensive technology is superior to ethanol's capital-intensive technology for generating total factor and labor income; the modern ethanol sector generates more capital income than the traditional ethanol sector. Unskilled agriculture labor receives the same labor income from both ethanol sectors. However, unskilled non-agriculture labor receives significantly more labor income from the labor-intensive ethanol sector than from the capital-intensive ethanol sector. Labor costs are significantly higher for the labor-intensive technology than for the capital-intensive technology. This is because agricultural employment associated with the traditional ethanol sector is three times greater than for the modern ethanol sector.

The labor intensive technologies of the agriculture and manufacturing sectors produce more total labor and capital income, more agriculture labor income, and more labor income to unskilled agriculture workers than the comparative capital-intensive technologies. However, the capital-intensive technologies raise more total non-agriculture workers income and more labor income to unskilled non-agriculture workers. This suggests that labor-intensive technologies contribute more income to agriculture labor as well as unskilled agriculture labor; furthermore, capital-intensive technologies contribute more to non-agriculture labor and unskilled non-agriculture labor. The capital-intensive technology of the service sectors is the only case of a capital-intensive technology providing more factor income than the labor-intensive technology.

## HYPOTHESIS THREE: TECHNOLOGY CHOICE AND HOUSEHOLD INCOME

Hypothesis three analyzes the effect of sectoral growth on household income. Do labor-intensive technologies contribute more to poverty alleviation than capital-intensive technologies? The SAM-based modeling makes it possible to examine the effects of growth in specific economic sectors on household poverty. Decomposing the accounting multiplier shows the linkages in the economy to household income.

This hypothesis posits that the implementation of labor-intensive technologies increases the income received by the lower income rural and urban households more than the capital-intensive technologies. The first part of the hypothesis determines whether Brazil's ethanol sectors provide more income to households in poverty than the gasoline sector: rural workers (HH3) , rural managers (HH4), urban organized labor (HH8), and urban non-organized labor (HH9). The second part of the hypothesis examines the impact of the agriculture, manufacturing, energy, and service sectors on the income of households in poverty. Structural path analysis is diagrammed to visualize the ways that the households are affected.

This hypothesis is tested within the submatrix of the fixed price multiplier matrix $M_{32}$. $M_{32}$ shows the effect of an exogenous change in the output of any production activity on household income.

The hypothesis is accepted if the household income fixed price multipliers for the ethanol sectors, traditional agriculture sector, non-durable consumer goods sector, and private services sector are greater than the multipliers for the gasoline sector, export agriculture sector, durable consumer goods sector, as well as the public and financial service sectors. Likewise, the hypothesis is rejected if the household income multipliers for the rural workers (HH3), rural managers (HH4), urban organized labor (HH8), and urban non-organized labor households (HH9) from the ethanol, traditional agriculture sector, non-durable consumer goods sector, and private services sector are lower than the household income generated by the gasoline sector, export agriculture sector, durable consumer goods sector, as well as the public and financial service sectors.

C.1.1. Ethanol and Gasoline Sectors and Household Income

Table 30 presents the household income from the ethanol and gasoline sectors. It indicates that total household income from the ethanol sectors (1775

Cr$+1723 Cr$=3498 Cr$) is greater than that from the gasoline sector (1732 Cr$). Furthermore, the traditional ethanol sector produces more household income (1775 Cr$) than the modern ethanol sector (1723 Cr$). The rural household income (HH 3,4) for both the modern and traditional ethanol sectors combined was (145 Cr$) (74+71), whereas, the rural household income for the gasoline sector was (31 Cr$). The poorest urban household income (HH 8,9) for both the modern and traditional ethanol sectors combined was (825 Cr$) (376+449) and (472 Cr$) for the gasoline sector. Poorer rural and urban household incomes benefit significantly more from ethanol production than from gasoline production.

Table 30. Gasoline and ethanol sector household income (Cr$).

| Household Income | | | | |
|---|---|---|---|---|
| | 1000 | Gasoline | Ethanol-M | Ethanol-T |
| Rural Capitalists | HH1 | 88 | 234 | 223 |
| Rural Sm. Producers | HH2 | 57 | 145 | 138 |
| RuralWorkers/Tenant Farmers | HH3 | 16 | 33 | 32 |
| Rural Mgrs./Prof. | HH4 | 15 | 41 | 39 |
| Urban Capitalists | HH5 | 466 | 381 | 382 |
| Urban Mgrs./Prof. | HH6 | 185 | 162 | 151 |
| Urban Sm. Producers | HH7 | 432 | 351 | 361 |
| Urban Organized Workers. | HH8 | 247 | 195 | 230 |
| Urban Non-Organized Workers | HH9 | 225 | 181 | 219 |
| TOTAL HOUSEHOLD INCOME | | 1732 | 1723 | 1775 |
| HH 3,4 income | | 31 | 74 | 71 |
| HH 8,9 income | | 472 | 376 | 449 |

Source: Fixed Price Multiplier Matrix.

Two findings are surprising. First, the modern ethanol sector provides slightly more income to all rural households and urban managers than the traditional ethanol sector. The modern ethanol sector generates more household income to rural capitalists (234 Cr$), rural small producers (145 Cr$), rural workers/tenant farmers (41 Cr$) and urban managers (162 Cr$) than the traditional ethanol sector's household income to rural capitalists (223 Cr$), rural small producers (138 Cr$), rural workers/tenant farmers (32 Cr$), and urban managers (151 Cr$). Second, the traditional ethanol sector contributes more to household incomes of urban capitalists (382 Cr$), urban small producers (361 Cr$), urban organized workers (230 Cr$), and urban non-organized workers (219 Cr$) than the modern ethanol sector's household income to urban capitalists (381 Cr$), urban small producers (351 Cr$), urban organized workers (195 Cr$), and urban non-organized workers. SPA in the next section helps to explain this finding.

Contrary to expectations, the modern ethanol sector provides slightly more income to all rural households and urban managers than the traditional ethanol sector. Table 31 shows the source of the household income. This discussion highlights the differences. The rural capitalist household receives more agriculture capital (.154 Cr$) path [32,19,4,9] from the modern ethanol sector than from the traditional ethanol sector (.143 Cr$) path [33,19,4,9]. The rural small producers households receive more income from the modern ethanol sector via skilled agriculture (.014 Cr$) path [32,19,2,10] and agriculture capital (.077 Cr$) path [32,19,4,10] than the traditional ethanol sector's skilled agriculture (.013 Cr$) path [33,19,2,10] and agriculture capital (.071 Cr$) path [33,19,4,10]. The rural managers and professionals also receive significantly more income from the modern ethanol sector via agriculture managers/professionals (.014 Cr$) path [32,19,3,12] and agriculture capital (.077 Cr$) path [32,19,4,12] than from the traditional ethanol sector's agriculture managers/professionals (.003 Cr$) path [33,19,3,12] and agriculture capital (.020 Cr$) path [33,19,4,12]. The rural workers households also receive more income from the modern ethanol sector than the traditional ethanol sector and is discussed in more detail in the next section.

The major reason that the modern ethanol sector generates more income to rural households is due to the greater agriculture capital that the traditional agriculture sector generates. More of this income is distributed to the rural households. SPA shows that between 76% and 81% of the household income is explained by the returns to agriculture labor and agriculture capital. It should also be noted that the modern ethanol sector purchases more from the traditional agriculture sector which gets distributed to agricultural factors of production.

Another interesting finding, is that the traditional ethanol sector contributes more to household incomes of urban small producers, urban organized labor, and urban non-organized labor than the modern ethanol sector. Table 31 shows again the source of the urban household income from the traditional ethanol sector. Urban small producers receive more from the traditional ethanol sector via the unskilled non-agriculture labor (.006 Cr$) path [33,5,15] and skilled non-agriculture labor (.009 Cr$) path [33,6,15] than from the modern ethanol sector's unskilled non-agriculture labor (.002 Cr$) path [32,5,15] and skilled non-agriculture labor (.005 Cr$) path [32,6,15]. The urban small producers households receive more agriculture capital from the modern ethanol sector (.045 Cr$) path [32,8,15] than from the traditional ethanol sector (.041 Cr$) path [33,8,15].

The urban organized workers households receive more income from the traditional ethanol sector than from the modern ethanol sector. The major difference in income is the higher income received by unskilled and skilled non-agriculture labor which gets distributed to the urban organized workers households. Urban organized workers receive significantly more income from the traditional ethanol sector via unskilled non-agriculture labor (.028 Cr$) path [33,5,16] and skilled non-agriculture labor (.025 Cr$) path [33,6,16] than from the modern ethanol sector's unskilled non-agriculture labor (.008 Cr$) path [32,5, 16] and skilled non-agriculture labor (.012 Cr$) path [32,6, 16].

Urban small producers, urban organized workers, and urban non-organized workers households receive more income from the traditional ethanol sector than from the modern ethanol sector. SPA shows that the traditional ethanol sector pays three times more to unskilled non-agriculture labor and two times more to skilled non-agriculture labor than the modern ethanol sector. This is due to the higher labor costs associated with the traditional ethanol sector. The urban non-organized workers household also receives more from the traditional ethanol sector and is discussed in more detail in the next section.

C.1.2 SPA of Household Income of the Ethanol and the Gasoline Sectors

The poles in Table 31 are: 9-rural capitalists, 10-rural small producers, 11-rural workers, 12-rural professionals, 13-urban capitalists, 14-urban professionals, 15-urban small producers, 16-urban organized laborers, 17-urban non-organized laborers, 32, modern ethanol sector, and 33-traditional ethanol sector.

Table 31 presents the global influence of an exogenous increase in both the modern and traditional ethanol sectors on household income. It can be seen that the global influence for the modern ethanol sector is greater than the global influence for the traditional ethanol sector for the following households: rural capitalists (.242 Cr$) [path 32,19,4,9] vs. (.231 Cr$) [path 33,19,4,9]; rural small producers (.15 Cr$)[path 32,19,1,10] vs. (.143 Cr$) [path 33,19,1,10]; rural workers (.035 Cr$) [path 32,19,2,11] vs. (.034 Cr$) [path 33,19,1,11]; rural professionals (.042 Cr$) [path 32,19,2,12] vs. (.040 Cr$) [path 33,19,2,12]; and urban professionals (.16 Cr$) [path 32,7,14] vs. (.15 Cr$) [path 33,7,14]. The global influence of the traditional ethanol is greater than the global influence of the modern ethanol sector for urban small producers (.361 Cr$) [path 33,5,15] vs. (.351 Cr$) [path 32,5,15], urban organized labor (.227 Cr$) [path 33,5,16] vs. (.191 Cr$) [path 32,5,16], and urban

Table 31. Effect of ethanol production on household income.

| | | Global | Direct | Path | Total | % of | Cum |
|---|---|---|---|---|---|---|---|
| Path | | Effect | Effect | Mult | Effect | Global | % |
| 32, 19, 4, 9 | | 0.242 | 0.154 | 1.265 | 0.195 | 80.8 | 80.8 |
| 33, 19, 4, 9 | | 0.231 | 0.143 | 1.265 | 0.181 | 78.3 | 78.3 |
| 32, 19, 1, 10 | | 0.15 | 0.002 | 1.256 | 0.002 | 1.4 | 1.4 |
| 32, 19, 2, 10 | | | 0.014 | 1.259 | 0.018 | 12 | 13.5 |
| 32, 19, 4, 10 | | | 0.077 | 1.272 | 0.098 | 65.4 | 78.9 |
| 33, 19, 1, 10 | | 0.143 | 0.002 | 1.256 | 0.002 | 1.4 | 1.4 |
| 33, 19, 2, 10 | | | 0.013 | 1.259 | 0.017 | 11.7 | 13 |
| 33, 19, 4, 10 | | | 0.071 | 1.272 | 0.091 | 63.3 | 76.4 |
| 32, 19, 1, 11 | | 0.035 | 0.004 | 1.235 | 0.005 | 15.6 | 15.6 |
| 32, 19, 2, 11 | | | 0.014 | 1.24 | 0.018 | 51.3 | 66.9 |
| 33, 19, 1, 11 | | 0.034 | 0.004 | 1.235 | 0.005 | 15 | 15 |
| 33, 19, 2, 11 | | | 0.013 | 1.24 | 0.017 | 49.3 | 64.2 |
| 32, 19, 2, 12 | | 0.042 | 0.002 | 1.238 | 0.003 | 6 | 6 |
| 33, 19, 2, 12 | | 0.04 | 0.002 | 1.238 | 0.002 | 5.8 | 5.8 |
| 32, 19, 3, 12 | | | 0.004 | 1.226 | 0.004 | 10.4 | 16.3 |
| 33, 19, 3, 12 | | | 0.003 | 1.226 | 0.004 | 10 | 15.8 |
| 32, 19, 4, 12 | | | 0.021 | 1.258 | 0.027 | 64 | 80.3 |
| 33, 19, 4, 12 | | | 0.02 | 1.258 | 0.025 | 62 | 77.9 |
| 32, 8, 13 | | 0.383 | 0.058 | 1.52 | 0.088 | 23 | 23 |
| 33, 8, 13 | | 0.383 | 0.052 | 1.52 | 0.079 | 20.7 | 20.7 |
| 32, 7, 14 | | 0.161 | 0.017 | 1.101 | 0.019 | 11.8 | 11.8 |
| 33, 7, 14 | | 0.15 | 0.005 | 1.102 | 0.006 | 3.9 | 3.9 |
| 32, 5, 15 | | 0.351 | 0.002 | 1.466 | 0.003 | 0.8 | 0.8 |
| 33, 5, 15 | | 0.361 | 0.006 | 1.466 | 0.009 | 2.5 | 2.5 |
| 32, 6, 15 | | | 0.005 | 1.469 | 0.007 | 1.9 | 2.7 |
| 33, 6, 15 | | | 0.009 | 1.469 | 0.014 | 3.8 | 6.3 |
| 32, 8, 15 | | | 0.045 | 1.578 | 0.071 | 20.3 | 23 |
| 33, 8, 15 | | | 0.041 | 1.578 | 0.064 | 17.8 | 24.1 |
| 32, 5, 16 | | 0.191 | 0.008 | 1.277 | 0.01 | 5.4 | 5.4 |
| 33, 5, 16 | | 0.227 | 0.028 | 1.276 | 0.036 | 15.9 | 15.9 |
| 32, 5, 17 | | 0.178 | 0.011 | 1.251 | 0.014 | 7.9 | 7.9 |
| 32, 6, 17 | | | 0.008 | 1.291 | 0.011 | 6 | 13.9 |
| 32, 8, 17 | | | 0.002 | 1.65 | 0.004 | 2 | 15.9 |
| 33, 5, 17 | | 0.216 | 0.039 | 1.25 | 0.048 | 22.4 | 22.4 |
| 33, 6, 17 | | | 0.017 | 1.291 | 0.022 | 10.1 | 32.5 |
| 33, 8, 17 | | | 0.002 | 1.65 | 0.003 | 1.5 | 34 |

non-organized labor (.216 Cr$) [path 33,5,17] vs. (.178 Cr$) [path 33,2,5,17]. SPA shows that the modern ethanol sector generates more agriculture capital than the traditional ethanol sector and it gets distributed to the rural households. Furthermore, agriculture capital is the source of greater rural household income.

Diagramming the SPA provides a better visual understanding of the effect of technology choice in ethanol production on the rural and urban households in poverty. Figures 26 and 27 illustrate the links between the modern and traditional ethanol technologies on the household income of rural workers. Figures 26 and 27 show that ethanol production and the poorest rural household are linked via unskilled and skilled agriculture labor. Comparing figures 26 and 27 indicates that the modern ethanol technology generates more income to unskilled (.007 Cr$) and skilled (.031 Cr$) agriculture labor than the traditional ethanol technology income to unskilled (.006 Cr$) and skilled (.029 Cr$) agriculture labor. The rural workers households receive more income from the modern ethanol technique via skilled agriculture labor (.014 Cr$) than from the traditional ethanol technique via skilled agriculture labor (.013 Cr$). One explanation for this finding can be traced to the traditional agriculture sector. The traditional agriculture sector receives more from the modern ethanol sector (.675 Cr$) than from the traditional ethanol sector (.625 Cr$). This is consistent as the modern ethanol distilleries are responsible for two thirds of total ethanol production.

FIGURE 26. INCOME EFFECTS OF TRADITIONAL ETHANOL SECTOR ON POOREST RURAL HOUSEHOLDS.

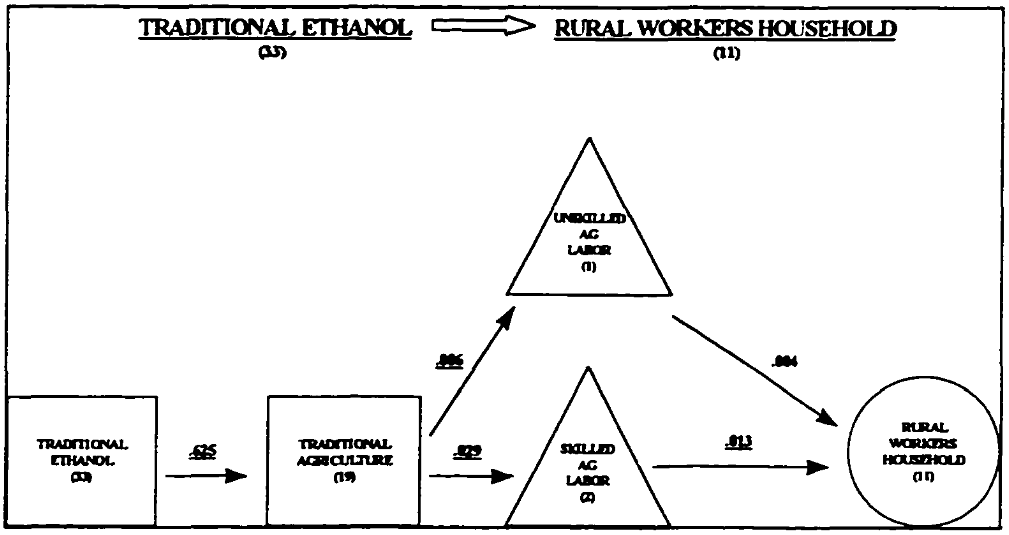
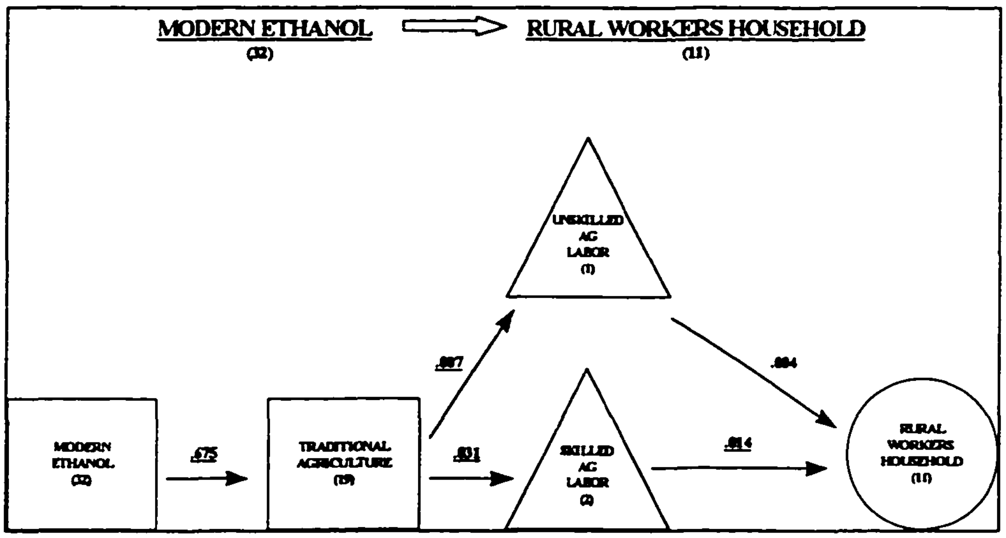



FIGURE 27. INCOME EFFECTS OF MODERN ETHANOL SECTOR ON POOREST RURAL HOUSEHOLDS.



Figures 28 and 29 provide the modern and traditional ethanol technology effects on the income of the poorest urban household: the poorest urban workers. Figures 28 and 29 show that ethanol production and the household income of the urban non-organized workers are linked via unskilled and skilled agriculture labor as well as non-agriculture capital.

Comparing figures 28 and 29 indicates that the traditional ethanol technology generates significantly more income to unskilled agriculture labor (.073 Cr$) and skilled agriculture labor (.052 Cr$) than the modern ethanol technology income to unskilled agriculture labor (.021 Cr$) and skilled agriculture labor (.025 Cr$). This finding is explained by differences in labor costs between traditional and modern ethanol technologies due to location. Wages in the northeast associated with the traditional ethanol sector are significantly higher than wages in the center south associated with the modern ethanol sector. Further inspection of the SPA diagram shows that the households of the urban non-organized workers receive more income from the traditional ethanol technique via unskilled agriculture labor (.039 Cr$) and skilled agriculture labor (.017 Cr$) than from the modern ethanol technique via unskilled agriculture labor (.011 Cr$) and skilled agriculture labor (.008 Cr$). While the modern ethanol technology generates more non-agriculture capital (.141 Cr$) than the traditional ethanol technology (.127 Cr$), both ethanol technologies raise the same amount of non-agriculture capital which gets distributed to the urban non-organized workers households (.002 Cr$). Interestingly, ethanol production and the poorest urban households have an additional link via non-agriculture capital that the poorest rural households do not have.

FIGURE 28. INCOME EFFECTS OF TRADITIONAL ETHANOL SECTOR ON POOREST URBAN HOUSEHOLDS.

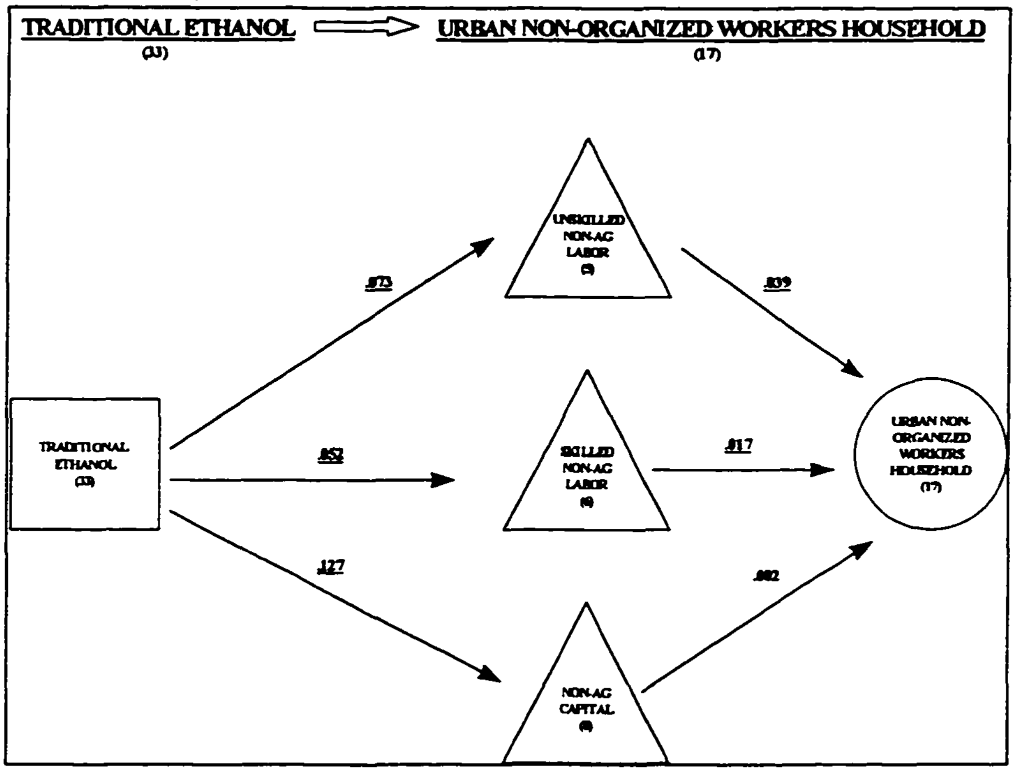
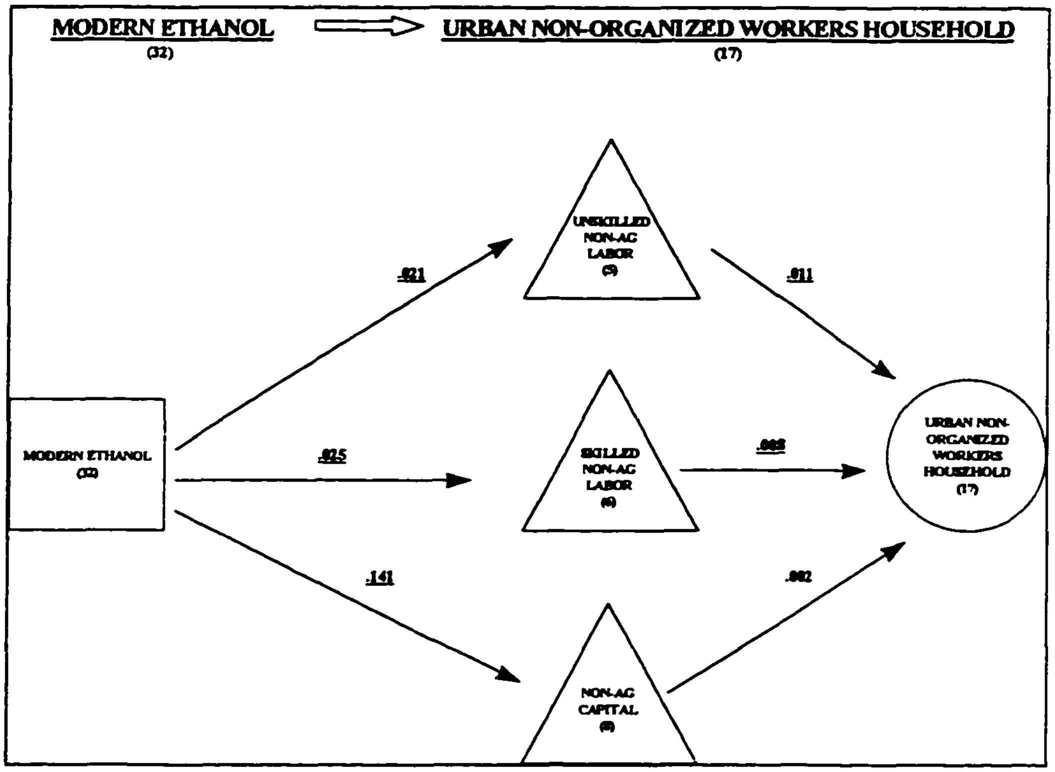


FIGURE 29. INCOME EFFECTS OF MODERN ETHANOL SECTOR ON POOREST URBAN HOUSEHOLDS.




C1.3. Household Income and Production Activities

Table 32 details the household income from different production activities. A comparison of the household income of the production activities shows that the agriculture and manufacturing labor-intensive technologies generate more total household income than the comparative capital-intensive technologies. The traditional agriculture sector provides more income to rural households and to rural households in poverty than the export agriculture sector. Conversely, the export agriculture sector generates more income to urban households and more income to

Table 32. Production activities and household income (Cr$).

| | | Ag-Export | Ag-Trad | Cons-Dur | Con-ND | Financial | Public | Private |
|---|---|---|---|---|---|---|---|---|
| | | K | L | K | L | K | K | L |
| Rural Capitalists | HH1 | 192 | 319 | 94 | 126 | 50 | 69 | 70 |
| Rural Sm. Producers | HH2 | 117 | 196 | 60 | 84 | 32 | 45 | 45 |
| Rural Workers/Ten. Farmers | HH3 | 27 | 44 | 17 | 25 | 9 | 13 | 13 |
| Rural Mgrs./Prof. | HH4 | 31 | 56 | 16 | 22 | 9 | 12 | 12 |
| Urban Capitalists | HH5 | 400 | 332 | 441 | 438 | 495 | 394 | 412 |
| Urban Mgrs./Prof. | HH6 | 167 | 138 | 188 | 178 | 178 | 236 | 181 |
| Urban Sm. Producers | HH7 | 372 | 308 | 411 | 406 | 440 | 413 | 394 |
| Urban Organized Workers. | HH8 | 215 | 177 | 242 | 231 | 200 | 372 | 258 |
| Urban Non-Organized Wkrs | HH9 | 201 | 165 | 225 | 214 | 182 | 358 | 242 |
| | | | | | | | | |
| Total Household Income | | 1721 | 1734 | 1694 | 1723 | 1594 | 1912 | 1628 |
| Total Rural Income | | 367 | 615 | 187 | 257 | 100 | 139 | 141 |
| Rural HH in Poverty | HH 3,4 | 58 | 100 | 33 | 47 | 18 | 25 | 25 |
| Total Urban Income | | 1355 | 1119 | 1506 | 1466 | 1495 | 1773 | 1487 |
| Urban HH in Poverty | HH 8,9 | 416 | 342 | 466 | 445 | 382 | 730 | 500 |

Source: Fixed Price Multiplier Matrix.

urban households in poverty. The non-durable consumer goods sector produces more income to rural households and rural households in poverty than the durable consumer goods sector. The durable consumer goods sector generates more urban household income and more income to urban households in poverty than the non-durable consumer goods sector. Examination of the service sectors reveals that the public services sector returns the most total household income, the most total urban household income, and the most income to urban households in poverty. The private services sector provides the most income to rural households of the service sectors. The public and private service sectors provides the same income to rural households in poverty which is greater than the financial services sector.

The economic sector which raises the most household income is the service sector followed by the agriculture and manufacturing sectors. The labor-intensive technologies generate more total household income than the comparative capital-intensive technologies in two of the three economic sectors: agriculture and manufacturing. The capital-intensive service sector provides more household income than the comparative labor-intensive service sector technology. Interestingly, the labor-intensive technologies of the agriculture, manufacturing, and service sectors contribute more to rural households than the comparative capital-intensive technologies.

C.1.4. SPA of Poorest Household Income of the Production Activities

SPA is applied to assess the direct and indirect effects of an exogenous increase in the production activities of the agriculture, manufacturing, and services sectors on the household income of the poorest households: rural workers/tenant farmers and urban non-organized labor. It can be seen from Table 33 that in some cases the indirect effects are greater than the direct effects.

Table 33 includes the following poles: 18-export agriculture; 24-consumer non-durable goods sector; 11-rural workers household.

Table 33. Effect of select production activities on the poorest rural household incomes.

| Path | | Global Effect | Direct Effect | Path Mult | Total Effect | % of Global | Cum % |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 18, 1, 11 | | 0.029 | 0.004 | 1.247 | 0.004 | 15.6 | 15.6 |
| 18, 2, 11 | | | 0.006 | 1.255 | 0.007 | 24.9 | 40.5 |
| 19, 1, 11 | | 0.046 | 0.007 | 1.234 | 0.008 | 17.6 | 17.6 |
| 19, 2, 11 | | | 0.021 | 1.239 | 0.027 | 58 | 75.6 |
| 24, 19, 2, 11 | | 0.027 | 0.001 | 2.148 | 0.003 | 10.2 | 10.2 |
| 24, 20, 1, 11 | | | 0.002 | 1.968 | 0.004 | 14.8 | 25 |
| 24, 20, 2, 11 | | | 0.004 | 1.971 | 0.008 | 30.9 | 55.9 |

Table 33 considers only the global influence of the production activities on rural households. Of the seven production activities, only the traditional and export agriculture sectors and consumer non-durable goods sector have any significant effect on the household incomes of rural workers/tenant farmers. The global influence of an exogenous increase in export and traditional agriculture is (.029 Cr$) [path 18,1,11] and (.046 Cr$) [path 19,1,11], respectively. The proportion of the direct effects of rural workers household income from unskilled agriculture labor accounts for export agriculture is 15.6% [path 18,1,11]; whereas, the indirect effect of rural workers household income from skilled agriculture labor is 24.9% [path 18,2,11]. The proportion of the direct effects for traditional agriculture from unskilled agriculture labor is 17.6% [path 19,1,11]; while the indirect effects from skilled agriculture labor account for 58% [path 19,2,11]. The indirect effects of household income of rural workers/tenant farmers is particularly affected by the labor income of skilled agriculture workers. An exogenous increase in the production of non-durable consumer goods also increases the household income of rural workers/tenant farmers. The global influence is (.027 Cr$) [path 24,19,2,11] with the proportion of direct effects accounting for 10.2% [path 24,19,2,11]; the indirect effects equal 45.7% [14.8% (path 24,20,1,11) + 30.9% (path 24,20,2,11)]. SPA indicates that the traditional agriculture sector and consumer non-durable goods sector (the labor-intensive technologies) increase household income for rural workers/tenant farmers more than the export agriculture sector or consumer durable goods sector (capital-intensive technologies). This is due to the minimal linkages that the capital-intensive technologies have with the unskilled and skilled agriculture labor.

Figures 30 and 31 diagram the effects of the traditional agriculture sector and the export agriculture sector on the income of the poorest rural household income: the rural workers. Figure 30 shows that the traditional agriculture sector and rural workers household income are linked via unskilled agriculture labor and skilled agriculture labor. Figure 30 indicates that the traditional agriculture sector pays unskilled agriculture labor (.01 Cr$) of which a portion (.007 Cr$) is passed on to the

FIGURE 30. INCOME EFFECTS OF TRADITIONAL AGRICULTURE SECTOR ON POOREST RURAL HOUSEHOLDS.

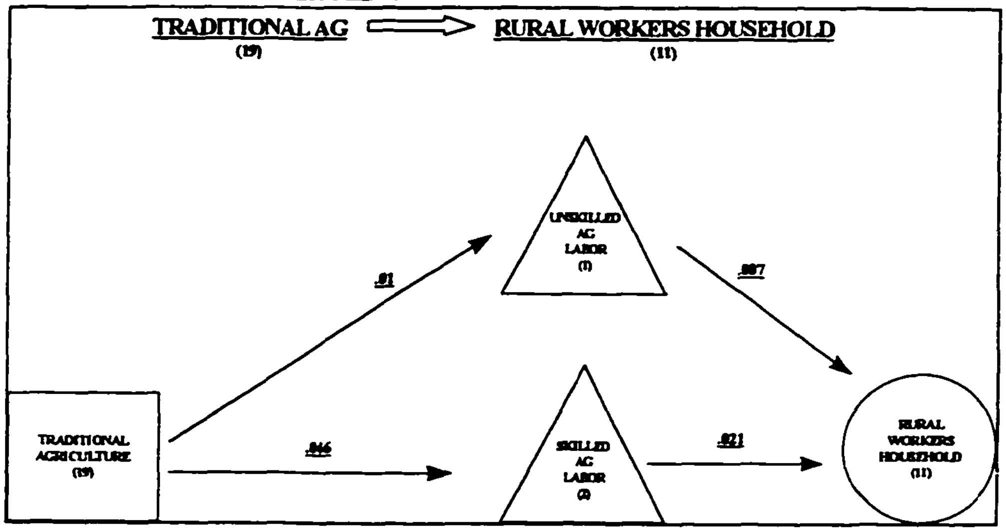
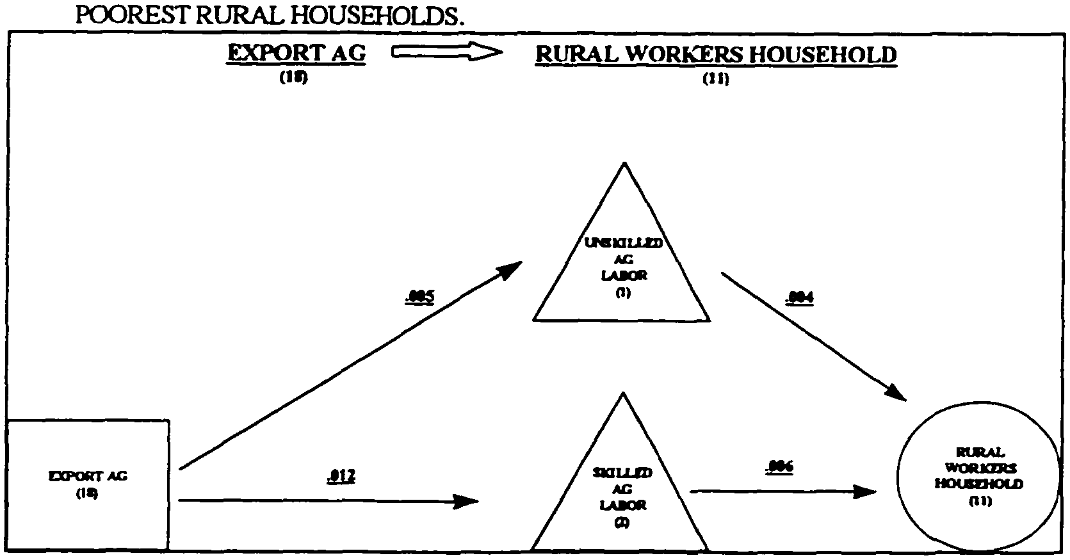



FIGURE 31. INCOME EFFECTS OF MODERN AGRICULTURE SECTOR ON THE POOREST RURAL HOUSEHOLDS.



rural workers household income. The traditional agriculture sector pays skilled agriculture labor (.046 Cr$) of which a portion (.021 Cr$) is passed on to the rural workers household income. Figure 31 indicates that the export agriculture sector pays unskilled agriculture labor (.005 Cr$) of which a portion (.004 Cr$) is passed on to the rural workers household income. The export agriculture sector pays skilled agriculture labor (.012 Cr$) of which a portion (.006 Cr$) is passed on to the rural workers household income. The traditional agriculture sector provides significantly more income to the poorest rural households than the export agriculture sector.

Table 34 includes the following sectors: 18-export agriculture; 19 traditional agriculture; 23-durable consumer goods; 24-non-durable consumer goods; 40-financial/commerical services; 43-public services; and 44-private services.

Table 34. Effect of select production activities on poorest urban household incomes.

| | | Global | Direct | Path | Total | % of | Cum |
|---|---|---|---|---|---|---|---|
| Path | | Effect | Effect | Mult | Effect | Global | % |
| | | | | | | | |
| 18, 45, 17 | | 0.197 | 0.011 | 4.595 | 0.05 | 25.4 | 25.4 |
| 19, 45, 17 | | 0.162 | 0.005 | 4.877 | 0.024 | 14.9 | 14.9 |
| 23, 5, 17 | | 0.221 | 0.011 | 1.653 | 0.018 | 8 | 8 |
| 24, 6, 17 | | 0.211 | 0.008 | 2.163 | 0.018 | 8.5 | 17 |
| 40, 5, 17 | | 0.179 | 0.015 | 2.575 | 0.04 | 22.2 | 22.2 |
| 43, 5, 17 | | 0.355 | 0.12 | 1.293 | 0.155 | 43.8 | 43.8 |
| 44, 5, 17 | | 0.239 | 0.05 | 1.425 | 0.071 | 29.8 | 29.8 |

Table 34 shows that the global influence of an exogenous increase in the production of agriculture, manufacturing, and services on the household income of urban non-organized labor is greater with the capital-intensive technology than the labor-intensive technology. Comparing the export and traditional agriculture sectors reveals that the global influence of an exogenous increase in the export agriculture sector on the household income of urban non-organized labor is greater than the traditional agriculture sector (.197 Cr$) [path 18,45,17] vs. (.162 Cr$) [path 19,45,17]. The global influence for the consumer durable goods sector is greater than the non-durable goods sector (.221 Cr$) [path 23,5,17] vs. (.211 Cr$) [path 24,6,17]. Analysis of the service sectors shows that the global influence of the public services sector ranks first for urban household income to non-organized labor and is (.355 Cr$) [path 43,5,17], followed by private services (.239 Cr$) [path 44,5,17], and financial/commercial services (.179 Cr$) [path 40,5,17]. The poorest urban households receive more income from the capital-intensive technology in the agriculture, manufacturing, and service sectors than the comparative labor-intensive technologies.

Figures 32 and 33 diagram the income effects of the non-durable consumer goods sector and the durable consumer goods sector on the poorest urban household income: the urban non-organized workers. Figure 32 shows that the non-durable consumer goods sector and urban non-organized workers household income are linked via unskilled non-agriculture labor, skilled non-agriculture labor, and non-agriculture capital. An indirect link between the non-durable goods sector and the urban non-organized workers household is the intermediate goods sector via unskilled non-agriculture labor. Figure 32 indicates that the non-durable consumer goods sector directly pays: a) unskilled non-agriculture labor (.016 Cr$) of which a portion (.008 Cr$) is passed on to the urban non-organized workers household income; b) skilled non-agriculture labor (.025 Cr$) of which a portion (.008 Cr$) is passed on to the urban non-organized workers household income; and c) non-agriculture capital (.104 Cr$) of which a portion (.002 Cr$) is passed on to the urban non-organized workers household income. The non-durable consumer goods sector

FIGURE 32. INCOME EFFECTS OF NON-DURABLE GOODS SECTOR ON THE POOREST URBAN HOUSEHOLDS.

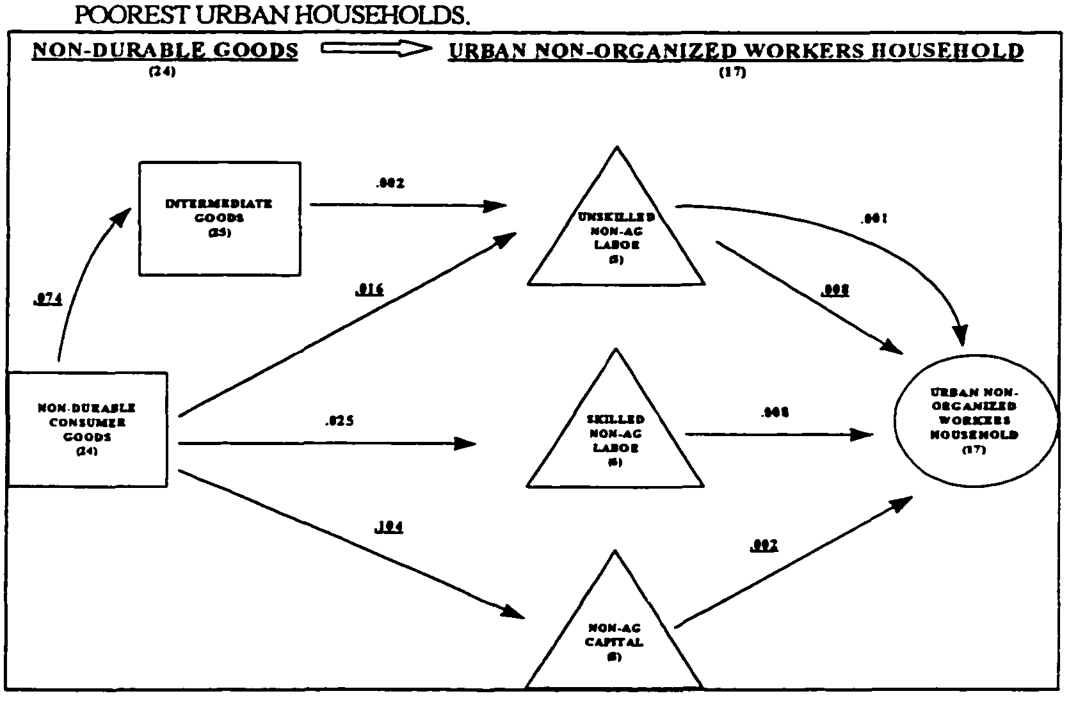
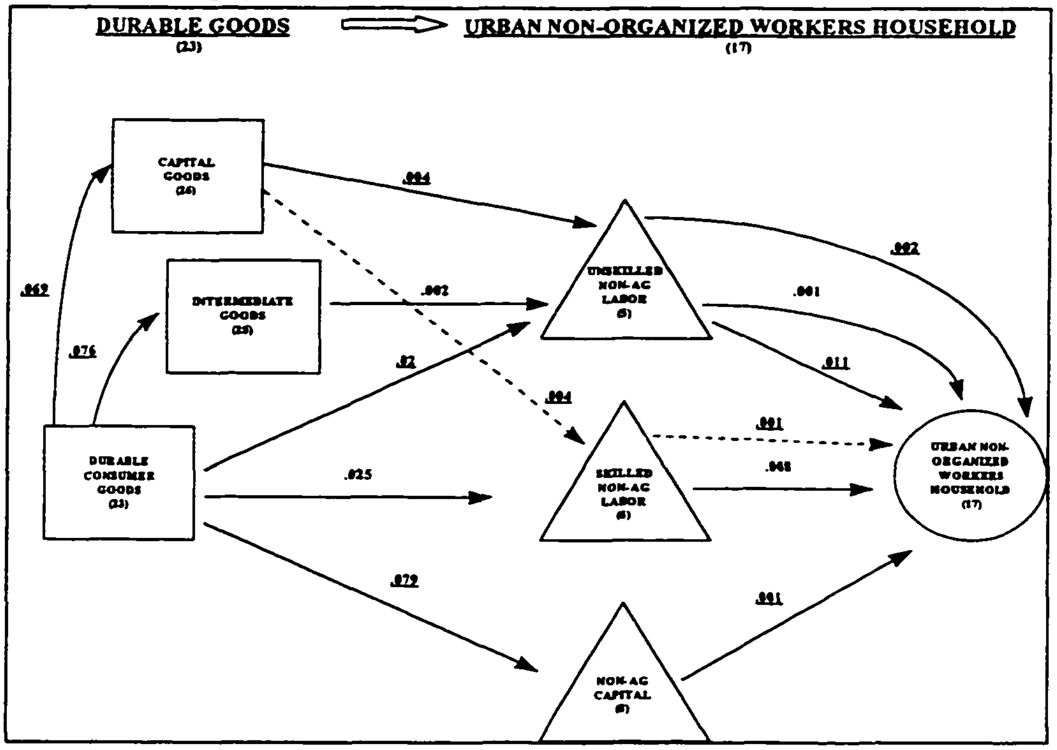


FIGURE 33. INCOME EFFECTS OF DURABLE GOODS SECTOR ON POOREST URBAN HOUSEHOLDS.




is indirectly linked to the urban non-organized workers household income via the intermediate goods sector. The non-durable goods sector pays the intermediate goods sector (.074 Cr$) of which (.002 Cr$) is paid to unskilled non-agriculture labor of which (.001 Cr$) is passed on to urban non-organized workers household income. Figure 33 indicates that the durable goods sector has an additional path (the capital goods sector) which the non-durable goods sector does not have. This additional link means that unskilled non-agriculture labor and skilled non-agriculture labor receive additional income which is in turn distributed to the poorest urban household. Figure 33 indicates that the durable consumer goods sector directly pays: a) unskilled non-agriculture labor (.02 Cr$) of which a portion (.011 Cr$) is passed on to the urban non-organized workers household income; b) skilled non-agriculture labor (.025 Cr$) of which a portion (.008 Cr$) is passed on to the urban non- organized workers household income; and c) non-agriculture capital (.079 Cr$) of which a portion (.001 Cr$) is passed on to the urban non-organized workers household income. The durable consumer goods sector is indirectly linked to the urban non-organized workers household income via the intermediate goods sector and the capital goods sector. The durable goods sector pays the intermediate goods sector (.076 Cr$) of which (.002 Cr$) is paid to unskilled non-agriculture labor of which (.001 Cr$) is passed on to urban non-organized workers household income. The durable goods sector pays the capital goods sector (.069 Cr$) of which (.004 Cr$) is paid to unskilled non-agriculture labor of which (.002 Cr$) is passed on to urban non-organized workers household income. In addition, the capital goods sector pays the skilled non-agriculture labor (.004 Cr$) of which a portion (.001 Cr$) is passed on to the income of the urban non-organized workers household. The urban non-organized workers household receives more income from the durable goods sector because of the additional indirect linkage to the capital goods sector which the non-durable goods sector does not have.

Hypothesis three is not accepted because the labor-intensive technologies do not always provide more household income than the capital-intensive technologies. The traditional ethanol sector provides the most household income, followed by the gasoline sector and modern ethanol sector. Contrary to expectations, the modern ethanol sector provides more income to all rural households and urban managers than the traditional ethanol sector. SPA shows that the modern ethanol sector generates more agriculture capital than the traditional ethanol sector and that it gets distributed to the rural households. Furthermore, agriculture capital is the source of greater rural household income. Interestingly, the traditional ethanol sector contributes more to the household incomes of urban small producers, urban organized labor, and urban non-organized labor than the modern ethanol sector. This is due to higher labor costs in the northeast associated with the traditional ethanol sector than the wages of the center-south associated with the modern ethanol sector.

The labor-intensive technologies generate more total household income than the comparative capital-intensive technologies in two of three economic sectors: agriculture and manufacturing. The capital-intensive service sector provides more household income than the comparative labor-intensive service sector technology. The traditional agriculture sector provides the most income to rural households and to rural households in poverty than the export agriculture sector. Conversely, the export agriculture sector generates more income to urban households and more income to urban households in poverty. The non-durable consumer goods sector produces more income to rural households and rural households in poverty. The durable consumer goods sector generates more urban household income and more income to urban households in poverty. Examination of the service sectors indicates that the public services sector returns the most total household income, the most total urban household income, and the most income to urban households in poverty. The private services sector provides the most income to rural households of the service sectors. The public and private service sectors contribute the same income to rural households in poverty which is greater than the financial services sector.

The poorest rural households receive more household income from the labor-intensive technologies of the agriculture, manufacturing, and service sectors. Meanwhile, the poorest urban households receive more income from the capital-intensive technologies. Diagramming the structural path analysis shows exactly how the economic sectors are linked to the factors of production, and in turn the linkages among the factors of production and households.

HYPOTHESIS FOUR: ENERGY SECTOR AND EMPLOYMENT, FACTOR INCOME, AND HOUSEHOLD INCOME

The ethanol industry would not have developed without government policies. The level of government support has decreased substantially. Government incentives and subsidies to the ethanol industry have benefited the ethanol producers and consumers, particularly higher income households. At the same time, the alternative fuel industry has also positively affected the lower income households to the extent that these households have direct or indirect linkages with the ethanol sector. It is hypothesized that a decrease in government support of the ethanol industry will negatively affect employment within the energy sector and income distribution to the rural and urban households in poverty: rural workers, rural managers, urban organized labor, and urban non-organized labor. The employment aspects are tested as in hypothesis two and the income distribution aspects are tested as in hypothesis three.

D.1.1 Employment and the Energy Sector

The employment effects of reduced government support of the ethanol industry can be determined by knowing the physical labor input coefficients and fixed price multiplier matrix. Similar to hypothesis two, the impacts of an exogenous decrease in spending by the government sector on the energy sector employment are calculated by multiplying the cruzeiro amount of government reduction by the employment multiplier matrix. This number indicates the employment effects (jobs reduced) due to an exogenous reduction in government expenditures.

Table 35 presents the employment multipliers for the energy sector. An exogenous decrease in expenditures in the energy sector would result in significant job losses in the energy sector. A million cruzeiro decrease in the energy sector would

Table 35. Energy sector employment multipliers

| Total Employment Multiplier - Energy Sector | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1000000 | | | | | | | | | | | | |
| | Coal | Bagasse | Kerosene | Oil | Gasoline | Ethanol-M | Ethanol-T | Gas | Electricity | Fuelwood | Veg. Char | Other |
| | K | L | K | K | K | L | L | K | L | L | L | K |
| Export Agriculture | 1.57 | 1.13 | 1.44 | 1.30 | 1.55 | 1.20 | 1.21 | 1.44 | 1.55 | 1.82 | 1.83 | 1.15 |
| Trad. Agriculture | 1.42 | 6.11 | 1.29 | 1.15 | 1.40 | 6.73 | 6.34 | 1.29 | 1.39 | 1.73 | 1.87 | 1.15 |
| Livestock | 0.39 | 0.37 | 0.36 | 0.31 | 0.39 | 0.39 | 0.40 | 0.35 | 0.38 | 0.44 | 0.44 | 0.38 |
| Mineral Extraction | 0.02 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Non-Mineral Ext. | 0.38 | 0.18 | 0.13 | 0.12 | 0.63 | 0.11 | 0.11 | 0.43 | 0.65 | 0.46 | 0.38 | 0.58 |
| Dur Goods | 0.24 | 0.18 | 0.22 | 0.20 | 0.24 | 0.19 | 0.19 | 0.22 | 0.24 | 0.28 | 0.28 | 0.17 |
| Non-Durable Goods | 0.60 | 0.46 | 0.54 | 0.47 | 0.59 | 0.49 | 0.50 | 0.53 | 0.58 | 0.65 | 0.66 | 0.59 |
| Intermediate Goods | 0.58 | 0.44 | 0.52 | 0.46 | 0.57 | 0.48 | 0.48 | 0.52 | 0.57 | 0.65 | 0.66 | 0.55 |
| Capital Goods | 0.14 | 0.10 | 0.11 | 0.10 | 0.14 | 0.11 | 0.11 | 0.12 | 0.14 | 0.15 | 0.15 | 0.15 |
| Coal | 0.96 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 |
| Bagasse | 0.01 | 0.72 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Kerosene | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Oil | 0.01 | 0.01 | 0.01 | 0.16 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 |
| Gasoline | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ethanol-M | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ethanol-T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Gas | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.39 | 0.01 | 0.01 | 0.01 | 0.01 |
| Electricity | 0.08 | 0.06 | 0.07 | 0.07 | 0.08 | 0.06 | 0.06 | 0.07 | 0.60 | 0.09 | 0.09 | 0.06 |
| Fuelwood | 0.68 | 0.51 | 0.62 | 0.56 | 0.67 | 0.54 | 0.54 | 0.62 | 0.67 | 8.72 | 0.80 | 0.47 |
| Veg. Charcoal | 0.34 | 0.25 | 0.31 | 0.28 | 0.34 | 0.26 | 0.26 | 0.31 | 0.33 | 0.39 | 8.32 | 0.24 |
| Other | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 1.21 |
| Civil Construction | 0.04 | 0.03 | 0.03 | 0.03 | 0.04 | 0.05 | 0.05 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 |
| Fin./Com. Services | 0.54 | 0.51 | 0.48 | 0.38 | 0.55 | 0.50 | 0.52 | 0.48 | 0.54 | 0.55 | 0.55 | 0.68 |
| Commerce | 0.39 | 0.36 | 0.34 | 0.27 | 0.38 | 0.34 | 0.37 | 0.34 | 0.37 | 0.38 | 0.38 | 0.39 |
| Transport/Comm. | 1.98 | 1.49 | 1.83 | 1.61 | 1.94 | 1.53 | 1.55 | 1.80 | 1.93 | 2.25 | 2.27 | 1.49 |
| Public Services | 0.06 | 0.05 | 0.05 | 0.04 | 0.06 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.05 |
| Private Services | 1.33 | 1.27 | 1.13 | 0.96 | 1.33 | 1.29 | 1.30 | 1.17 | 1.28 | 1.33 | 1.34 | 1.24 |
| Sum | 12 | 14 | 10 | 9 | 11 | 15 | 14 | 10 | 11 | 20 | 20 | 11 |

Source: Employment Multiplier Matrix.

lead to an estimated reduction of 157 jobs. The ethanol sectors would account for 29 of the 157 jobs - or 18% of the energy jobs. Employment losses in the renewable energy sectors (modern ethanol-15, traditional ethanol-14, bagasse-14, electricity-11, fuelwood-20, and vegetable charcoal-20) are significantly higher than the employment in the non-renewable energy sources (coal-12, gasoline-11, kerosene-10, oil-9, gas-10, and, other-11). Examination of the employment matrix shows that even though the direct employment effects of some of non-renewable energy sectors are larger than the direct employment effects of some renewable energy sectors, the total employment associated with the renewable energy sectors are larger than the non-renewable energy sectors because of the indirect effects. For example, the coal sector's direct employment is .96 and total employment is 12; bagasse's direct employment is .72 and total employment is 14. It is the indirect employment effects of the renewable energy sectors that account for renewable energy's greater employment than those of the non-renewable energy sectors. The renewable energy sectors generate more total employment than the non-renewable energy sectors.

D.2.1. Factor Income and Energy Sector

The energy sector can be further analyzed. The fixed price multiplier sub-matrix $M_{13}$ gives the factor income resulting from a change in the output of any energy sub-sector. Thus, the labor and capital income effects due to a change in the energy sector can be better understood.

Table 36 presents the energy sector factor income. Ranking the combined labor and capital incomes gives the following breakdown: traditional ethanol (1687 Cr$), modern ethanol (1639 Cr$), bagasse (1590 Cr$), gasoline (1562 Cr$), coal (1533 Cr$), vegetable charcoal (1492 Cr$), fuelwood (1477 Cr$), electricity (1464 Cr$), other (1368 Cr$), gas (1357 Cr$), kerosene (1315 Cr$), and oil (1072 Cr$). The ethanol industry generates the most factor income within the energy sector. The renewable energy sectors raise more total factor income than non-renewable energy sectors. Furthermore, renewable energy provides more agriculture labor and capital as well as more non-agriculture labor and capital than non-renewable energy.

Table 36 illustrates the effects of an exogenous change in the energy sector on factor incomes. It can be seen that the unskilled agriculture labor gains the most income from the ethanol sectors (each sector 12 Cr$), followed by bagasse (11 Cr$), and vegetable charcoal (7 Cr$). Skilled agriculture labor also takes in the most income from the modern ethanol sector (49 Cr$), followed by the traditional ethanol sector (47 Cr$), and bagasse (45 Cr$). Agriculture managers get the most income from the modern ethanol sector (5 Cr$), followed by the traditional ethanol sector (4 Cr$) and bagasse (4 Cr$). Agriculture capital obtains the most return from the modern ethanol sector (403 Cr$), followed by the traditional ethanol sector (383 Cr$), and bagasse (367 Cr$). The modern and traditional ethanol sectors generate the most income to both agriculture labor and agriculture capital of all the energy sub-sectors.

Table 36. Energy sector and factor income (Cr$).

| SAM-TECH, Brazil, 1985, Fixed Price Multiplier Matrix | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1000 | | | | | | | | | | | | |
| | Coal | Bag. | Kero. | Oil | Gasol. | Eth-M | Eth-T | Gas | Elect. | Fuelwd | Veg | Other |
| | K | L | K | K | K | L | L | K | L | L | L | K |
| Unskilled Ag. Labor | 6 | 11 | 5 | 5 | 6 | 12 | 12 | 5 | 5 | 6 | 7 | 5 |
| Skilled Ag. Labor | 19 | 45 | 17 | 15 | 19 | 49 | 47 | 17 | 18 | 22 | 23 | 16 |
| Mgrs/Prof. Ag Labor | 1 | 4 | 1 | 1 | 1 | 5 | 4 | 1 | 1 | 1 | 1 | 1 |
| Ag.Capital | 131 | 367 | 120 | 107 | 129 | 403 | 383 | 119 | 129 | 155 | 163 | 107 |
| Total ag labor & capital | 157 | 427 | 143 | 127 | 155 | 469 | 445 | 143 | 154 | 185 | 194 | 130 |
| | | | | | | | | | | | | |
| Unskilled Non Ag. Labor | 173 | 158 | 180 | 115 | 173 | 148 | 202 | 155 | 158 | 168 | 179 | 151 |
| Skilled Non-Ag. Labor | 197 | 172 | 195 | 130 | 220 | 167 | 196 | 188 | 203 | 201 | 203 | 191 |
| Mgrs/Prof. Non-Ag Labor | 75 | 61 | 67 | 53 | 75 | 73 | 62 | 67 | 71 | 74 | 74 | 67 |
| Non-Ag. Capital | 932 | 772 | 731 | 647 | 940 | 782 | 782 | 806 | 879 | 849 | 841 | 828 |
| Total non-ag labor & capital | 1377 | 1162 | 1172 | 945 | 1408 | 1170 | 1242 | 1215 | 1311 | 1292 | 1298 | 1238 |
| Total labor & capital. | 1690 | 2017 | 1458 | 1199 | 1717 | 2107 | 2132 | 1500 | 1618 | 1662 | 1686 | 1497 |

Source: Fixed Price Multiplier Matrix.

Unskilled non-agriculture labor gains the most income from the traditional ethanol sector (202 Cr$), followed by the kerosene sector (180 Cr$), the gasoline sector (173 Cr$), and the coal sector (173 Cr$). Skilled non-agriculture labor obtained the most income from the gasoline sector (220 Cr$), followed by the electricity and vegetable charcoal sectors (each 203 Cr$), and the fuelwood sector (201 Cr$). Non-agriculture managers received the most income from the gasoline and coal sectors (each 75 Cr$), then fuelwood and vegetable charcoal (each 74 Cr$). Non-agriculture capital gained the highest return from the gasoline sector (940 Cr$), followed by the coal sector (932 Cr$), fuelwood sector (849 Cr$), and vegetable charcoal sector (841 Cr$). Interestingly, analysis of the non-agriculture labor and capital factor income accounts suggests that the gasoline sector provides the most income to non-agriculture capital, non-agriculture managers, and skilled non-agriculture labor.

D.2.2. SPA of Factor Income of the Energy Sector

Decomposition of the accounting multipliers i.e., the global influence from the energy sub-sectors poles to unskilled labor income, reveals some differences from the employment multipliers. While the employment multipliers for the renewable energy sub-sectors were significantly higher than those of the non-renewable energy sectors, the energy sub-sectors factor income received by unskilled workers differs considerably.

The poles in Table 37 includes: 28-bagasse, 32-modern ethanol, 33-traditional ethanol, 1-unskilled agriculture workers.

Table 37 presents the global influence of the energy sub-sectors on unskilled agriculture worker income. Only three sectors have a significant effect on unskilled agriculture labor income: the modern and ethanol sectors and the bagasse sector. The global influence of the modern ethanol sector is (.013 Cr$) [path 33,1]; while the global influence is (.012 Cr$) for the traditional ethanol sector [path 33,1] and (.012 Cr$) for the bagasse sector [path 28,1]. These three renewable energy sectors

Table 37. Energy sector effects on unskilled non-agriculture labor income.

| | | Global | Direct | Path | Total | % of | Cum |
|---|---|---|---|---|---|---|---|
| Path | | Effect | Effect | Mult | Effect | Global | % |
| 28, 19, 1 | | 0.012 | 0.003 | 2.156 | 0.007 | 63.3 | 63.3 |
| 32, 19, 1 | | 0.013 | 0.007 | 1.226 | 0.008 | 64.6 | 64.6 |
| 33, 19, 1 | | 0.012 | 0.006 | 1.226 | 0.008 | 61.9 | 61.9 |

increase the income to unskilled agriculture workers via the traditional agriculture sector. Renewable energy provides more labor income to unskilled agriculture workers than the non-renewable energy sectors.

Table 38 includes the following poles: 27-coal, 28-bagasse, 29-kerosene, 30-oil, 31-gasoline, 32-modern ethanol, 33-traditional ethanol, 34-gas, 35-electricity, 36-fuelwood, 37-vegetable charcoal, 38-other, 5-unskilled non-agriculture workers.

Table 38 presents the global influence of the energy sub-sectors on unskilled non-agriculture labor income. Table 38 ranks the global influence of the energy sub-sectors on unskilled non-agricultural labor income as follows: traditional ethanol technology (.195 Cr$) [path 33,5], kerosene (.175 Cr$) [path 29,5], vegetable charcoal (.173 Cr$) [path 37,5], coal (.167 Cr$) [path 31,5], gasoline (.167 Cr$) [path 27,5], fuelwood (.162 Cr$) [path 36,5], electricity (.153 Cr$) [path 35,5], bagasse (.152 Cr$) [path 28,5], gas (.149 Cr$) [path 34,5], other (.147 Cr$) [path 38,22,5], modern ethanol sector (.142 Cr$) [path 32,5], and oil (.111 Cr$) [path 30,5]. Renewable energy provides more income to unskilled non-agriculture workers than the non-renewable energy sectors.

Table 38. Energy sector effects on unskilled non-agriculture labor income.

| Path | | Global Effect | Direct Effect | Path Mult | Total Effect | % of Global | Cum % |
|---|---|---|---|---|---|---|---|
| 27, 5 | | 0.167 | 0.02 | 1.161 | 0.023 | 13.6 | 13.6 |
| 28, 5 | | 0.152 | 0.02 | 2.015 | 0.04 | 26.1 | 26.1 |
| 29, 5 | | 0.175 | 0.05 | 1.147 | 0.057 | 32.6 | 32.6 |
| 30, 5 | | 0.111 | 0.002 | 1.256 | 0.003 | 2.3 | 2.3 |
| 30, 45, 24, 5 | | | 0.001 | 5.33 | 0.007 | 6.5 | 8.8 |
| 30, 45, 25, 5 | | | 0.002 | 6.759 | 0.016 | 14.5 | 23.3 |
| 30, 45, 42, 5 | | | 0.003 | 4.838 | 0.014 | 12.6 | 35.9 |
| 31, 5 | | 0.167 | 0.015 | 1.165 | 0.017 | 10.3 | 10.3 |
| 32, 5 | | 0.142 | 0.021 | 1.143 | 0.024 | 17.1 | 17.1 |
| 33, 5 | | 0.195 | 0.073 | 1.143 | 0.083 | 42.7 | 42.7 |
| 34, 5 | | 0.149 | 0.016 | 1.162 | 0.018 | 12.2 | 12.2 |
| 35, 5 | | 0.153 | 0.002 | 1.32 | 0.003 | 2 | 2 |
| 35, 22, 5 | | | 0.012 | 1.339 | 0.016 | 10.5 | 12.5 |
| 35, 45, 24, 5 | | | 0.001 | 5.279 | 0.007 | 4.9 | 17.4 |
| 35, 45, 25, 5 | | | 0.002 | 6.695 | 0.017 | 10.8 | 28.2 |
| 35, 45, 42, 5 | | | 0.003 | 4.793 | 0.014 | 9.4 | 37.6 |
| 36, 5 | | 0.162 | 0.002 | 1.249 | 0.003 | 1.8 | 1.8 |
| 37, 5 | | 0.173 | 0.015 | 1.191 | 0.017 | 10.1 | 10.1 |
| 38, 22, 5 | | 0.147 | 0.011 | 1.183 | 0.013 | 9.1 | 9.1 |

Further inspection of the SPA results shows that for several energy sub-sectors, the indirect effects on income to unskilled non-agricultural labor are greater than the direct effects. For example, the oil sector's direct labor income to non-agricultural workers is 2.3% [path 30,5], while the indirect effects via the non-durable consumer goods is 6.5% [path 30,45,24,5], intermediate goods sector 14.5% [path 30,45,25,5], and the transportation sector 12.6% [path 30,45,42,5]. The electricity sector's direct effect is 2% of the global influence [path 35,5], while the indirect effects are via the non-mineral sector 10.5% [path 35,22,5], consumer non-durable goods sector 4.9% [path 35,45,22,5], intermediate goods sector 10.8% [path

35,45,25,5], and the transportation sector 9.4% [35,45,42,5]. The indirect effects are also greater than the direct effects of an exogenous increase in the fuelwood sector on urban unskilled workers income. SPA suggests that if policy makers are interested in the effect of energy policy on unskilled workers, then investment in some energy sub-sectors may be more effective than others because of their intersectoral linkages. SPA reveals that the oil, electricity, fuelwood, and vegetable charcoal sectors have greater indirect effects than the direct effects of the coal, bagasse, kerosene, gasoline, modern and traditional ethanol sectors, gas, and the other energy sub-sectors on non-agricultural unskilled labor income.

D.3.1 Household Income and the Energy Sector

As stated in Hypothesis 3, $M_{32}$ gives the household income distribution resulting from a change in output of any production activity. This hypothesis tests the effects of an exogenous decrease in government expenditures on the energy sector and subsequent household income effects.

Table 39 presents the energy sector household income. It can be seen that the following energy sub-sectors provide the most total household income: traditional ethanol (1775 Cr$), vegetable charcoal (1737 Cr$), gasoline (1732 Cr$), modern ethanol (1723 Cr$), fuelwood (1720 Cr$), coal (1708 Cr$), bagasse (1666 Cr$), electricity (1644 Cr$), gas (1527 Cr$), kerosene (1496 Cr$), other (1454 Cr$), and oil (1240 Cr$).

Table 39. Energy sector household income (Cr$).

| Energy Sector Household | Coal | Bagas. | Keros. | Oil | Gasol. | Ethan-M | Ethan-T | Gas | Electr. | Fuelwd | Veg. Char | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1000 | K | L | K | K | K | L | L | K | L | L | L | K |
| Rural Capitalists | 89 | 214 | 82 | 73 | 88 | 234 | 223 | 82 | 88 | 106 | 110 | 71 |
| Rural Sm. Prod. | 58 | 132 | 53 | 47 | 57 | 145 | 138 | 53 | 57 | 68 | 71 | 46 |
| Rural Workers | 16 | 31 | 15 | 13 | 16 | 33 | 32 | 15 | 16 | 19 | 19 | 13 |
| Rural Mgrs./Prof. | 15 | 37 | 14 | 13 | 15 | 41 | 39 | 14 | 15 | 18 | 19 | 12 |
| Urban Capitalists | 464 | 374 | 375 | 334 | 466 | 381 | 382 | 406 | 441 | 444 | 441 | 395 |
| Urban Mgrs./Prof. | 185 | 147 | 158 | 134 | 185 | 162 | 151 | 164 | 176 | 184 | 184 | 157 |
| Urban Sm. Prod. | 426 | 347 | 356 | 306 | 432 | 351 | 361 | 377 | 409 | 414 | 413 | 366 |
| Urban Organ. Lab. | 236 | 199 | 229 | 166 | 247 | 195 | 230 | 218 | 232 | 243 | 249 | 206 |
| U. Non-Organ. Lab | 218 | 186 | 214 | 154 | 225 | 181 | 219 | 200 | 211 | 224 | 231 | 188 |
| Total Income | 1708 | 1666 | 1496 | 1240 | 1732 | 1723 | 1775 | 1527 | 1644 | 1720 | 1737 | 1454 |

Source: Fixed Price Multiplier Matrix

Therefore, a million cruzeiros decrease in the production of the modern ethanol sector is estimated to result in total decreased household income of (1723 Cr$); the traditional ethanol sector is estimated to lose household income of (1775 Cr$). A million cruzeiro decrease in the gasoline sector results in household income loss of (1732 Cr$). These three sectors have among the highest household income multipliers in the entire economy. Therefore, reduced government support will significantly affect household income within the energy sector and the entire economy.

Renewable energy provides more rural and urban household income than the non-renewable energy sectors. The rural households receive (1904 Cr$) from the renewable energy sectors, compared to (968 Cr$) from the non-renewable energy sector. The urban households obtain (8363 Cr$) from renewable energy and (8187 Cr$) from the non-renewable energy sectors. Rural households take in almost twice as much income from the renewable energy sectors than from non-renewable energy sectors. Urban households on the other hand receive only slightly more from the renewable energy than from the non-renewable energy sectors. For households in poverty, renewables raise rural incomes by (319 Cr$) compared to (171 Cr$) by the non-renewables. Renewable energy increases urban incomes by (2601 Cr$) compared to (2502 Cr$) by non-renewable energy sectors. Renewable energy significantly and positively contributes to household income in Brazil. Renewable energy sectors provide more household income to rural and urban households and to those households in poverty than the non-renewable energy sectors.

D.3.2 SPA of the Household Income of the Energy Sector

Table 40 shows the effect of a change in the production of the energy sector on the household income of rural unskilled workers and urban non-organized workers. The indirect effects of energy production on the poorest rural and urban household incomes, are often larger than the direct effects.

The poles in Table 40 include: 27-coal, 28-bagasse, 29-kerosene, 30-oil, 31-gasoline, 32-modern ethanol, 33-traditional ethanol, 34-gas, 35-electricity, 36-fuelwood, 37-vegetable charcoal, 38-other, 11-rural workers, 17-urban non-organized labor.

Table 40. Energy sector effects on incomes of poorest rural and urban households.

| | | Global | Direct | Path | Total | % of | Cum |
|---|---|---|---|---|---|---|---|
| Path | | Effect | Effect | Mult | Effect | Global | % |
| 28, 19, 1, 11 | | 0.032 | 0.002 | 2.172 | 0.005 | 15.3 | 15.3 |
| 28, 19, 2, 11 | | | 0.007 | 2.18 | 0.016 | 50.3 | 65.6 |
| 32, 19, 1, 11 | | 0.035 | 0.004 | 1.235 | 0.005 | 15.6 | 15.6 |
| 32, 19, 2, 11 | | | 0.014 | 1.24 | 0.018 | 51.3 | 66.9 |
| 33, 19, 1, 11 | | 0.034 | 0.004 | 1.235 | 0.005 | 15 | 15 |
| 33, 19, 2, 11 | | | 0.013 | 1.24 | 0.017 | 49.3 | 64.2 |
| | | | | | | | |
| 27, 5, 17 | | 0.215 | 0.01 | 1.269 | 0.013 | 6.1 | 6.1 |
| 28, 5, 17 | | 0.183 | 0.01 | 2.204 | 0.023 | 12.6 | 12.6 |
| 29, 5, 17 | | 0.212 | 0.026 | 1.255 | 0.033 | 15.6 | 15.6 |
| 30, 5, 17 | | 0.151 | 0.001 | 1.367 | 0.001 | 1 | 1 |
| 31, 5, 17 | | 0.222 | 0.008 | 1.272 | 0.01 | 4.5 | 4.5 |
| 32, 5, 17 | | 0.178 | 0.011 | 1.251 | 0.014 | 7.9 | 7.9 |
| 33, 5, 17 | | 0.216 | 0.039 | 1.25 | 0.048 | 22.4 | 22.4 |
| 34, 5, 17 | | 0.197 | 0.008 | 1.269 | 0.011 | 5.3 | 5.3 |
| 35, 5, 17 | | 0.208 | 0.001 | 1.427 | 0.002 | 0.8 | 0.8 |
| 36, 5, 17 | | 0.221 | 0.001 | 1.357 | 0.002 | 0.8 | 0.8 |
| 37, 5, 17 | | 0.228 | 0.008 | 1.299 | 0.01 | 4.4 | 4.4 |
| 38, 22, 5, 17 | | 0.187 | 0.006 | 1.286 | 0.008 | 4.1 | 4.1 |

SPA indicates that the indirect effects are greater than the direct effects on the household income to rural workers for the bagasse and ethanol sectors. For example, the proportion of the indirect effects of an exogenous decrease in the bagasse sector on the rural workers is 50.3% [path 28,19,2,11] via skilled agriculture labor, while the proportion of the direct effects is 15.3% [path 28,19,1,11] via unskilled agriculture labor. Examination of Table 40 reveals that for the poorest rural households, the indirect effects are greater than the direct effects for both the modern and traditional ethanol sectors.

Table 40 also presents the global influence of an exogenous decrease in the energy sector on the household income of urban non-organized workers. It suggests that the household income of urban non-organized workers will be most affected by a decrease in the following energy sub-sectors: vegetable charcoal (.228 Cr$) [path 37,5,17], gasoline (.222 Cr$) [path 31,5,17], fuelwood (.221 Cr$) [path 36,5,17], traditional ethanol (.216 Cr$) [path 33,5,17], coal (.215 Cr$) [path 27,5,17], kerosene (.212 Cr$) [path 29,5,17], electricity (.208 Cr$) [path 35,5,17], gas (.197 Cr$) [path 34,5,17], other (.187 Cr$) [path 38,22,5,17], bagasse (.183 Cr$) [path 28,5,17], modern ethanol (.178 Cr$) [path 32,5,17], and oil (.151 Cr$) [path 30,5,17]. Three of the top five energy sub-sectors that most affect the incomes of the poorest urban households are renewables (vegetable charcoal, fuelwood, and traditional ethanol) and could be a priority of industrial policies that affect urban households in poverty.

Hypothesis four is accepted because the renewable energy sectors provide relatively more employment, factor income, and household income effects of the energy sub-sectors. The renewable energy sectors provide more total employment than the non-renewable energy sectors. Renewable energy sectors are relatively more labor-intensive than the non-renewable energy sectors.

The energy sector affects agriculture and non-agriculture factor income differently. Unskilled and skilled agriculture labor receives the most income from the ethanol sectors followed by bagasse and vegetable charcoal. The modern and traditional ethanol sectors provide the greatest income to both agriculture labor and agriculture capital of all the energy sub-sectors. The renewable energy sectors raise more factor income than the non-renewable energy sectors. Renewable energy generates more agriculture labor and agriculture capital income as well as more non-agriculture labor and non-agriculture capital income.

The energy sector's impact on household income is interesting. The traditional ethanol sector provides the most household income followed by the vegetable charcoal sector, gasoline sector, modern ethanol sector, coal sector, bagasse sector, electricity sector, gas sector, kerosene sector, and other sector.

Renewable energy provides more rural and urban household income than non-renewable energy. Rural households receive almost twice as much income from renewable energy sectors than from non-renewable energy sectors. Urban households on the other hand obtain only slightly more from the renewable energy than from the non-renewable energy sectors. Renewable energy significantly and positively contributes to household income in Brazil. Renewable energy sectors provide more household income to rural and urban households and to those households in poverty than non-renewable energy sectors.

HYPOTHESIS FIVE: TECHNOLOGY CHOICE AND $CO_2$ COSTS

In Brazil, the two major sources of carbon emissions are deforestation and the energy sector. The total carbon emissions are estimated to be approximately 256 million tons of carbon (MtC). Carbon emissions due to deforestation are not included in this analysis because of data limitations. Peer-reviewed studies exist which detail the energy sector carbon emissions. The energy sector emissions are estimated to be about 70 MtC. $CO_2$ emissions due to energy consumption and production were allocated to the following sectors: households (10%), agriculture (7.5%), industry (38%), energy (10.5%), transportation (33%), and services (1%).[171]

It is hypothesized that the adoption of labor-intensive technologies generates less $CO_2$ costs than capital-intensive technologies. The first part of the hypothesis ascertains the $CO_2$ costs of the energy sector. The second part of the hypothesis examines the $CO_2$ costs of the agriculture, manufacturing, and service sectors. Then energy consumption of these sectors is analyzed to determine which economic sectors are the more environmentally friendly.

Hypothesis five is accepted if the $CO_2$ costs of the ethanol sectors, traditional agriculture sector, non-durable consumer goods sector, and private services sector are less than those for the gasoline sector, export agriculture sector, durable

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[171]Emilio La Rovere, "Scenarios for Mitigating Greenhouse Gases Emissions and

consumer goods sector, and the public services sector as well as the financial services sector. The hypothesis is rejected if the $CO_2$ costs of the labor-intensive technologies are greater than the capital-intensive technologies.

E.1.1. $CO_2$ Costs and the Energy Sector

Given that the transportation sector accounts for 33% of energy-related $CO_2$ emissions, an alternative to petroleum-based transportation fuel merits serious evaluation. It is hypothesized that the development of alternative renewable energy sources, particularly for motor vehicle transportation significantly decreases emissions that contribute to global warming and air pollution, i.e., the use of ethanol has significantly lower $CO_2$ emission costs than conventional gasoline.

The energy sector accounts for 10.5% of the total energy sector-related $CO_2$ costs. Table 41 ranks the energy sub-sectors from the lowest to the highest $CO_2$ costs: other (2223 Cr$), bagasse (2303 Cr$), modern ethanol (2431 Cr$), traditional ethanol (2442 Cr$), oil (2757 Cr$), gas (3027 Cr$), kerosene (3030 Cr$), gasoline (3242 Cr$), electricity (3251 Cr$), coal (3279 Cr$), fuelwood (3863 Cr$), and vegetable charcoal (3884 Cr$).

The ethanol sectors have less $CO_2$ costs than the gasoline sector. The traditional ethanol sector (2442 Cr$) has slightly higher $CO_2$ emissions costs than the modern ethanol sector (2431 Cr$). This is due to the traditional ethanol sector's

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consumer goods sector, and the public services sector as well as the financial services sector. The hypothesis is rejected if the $CO_2$ costs of the labor-intensive technologies are greater than the capital-intensive technologies.

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Promoting Sustainable Energy Development in Brazil," 345.

greater linkages to the traditional agriculture sector and transportation sector. Gasoline $CO_2$ costs on the other hand, increase by (3242 Cr$). The renewable energy sectors have a little higher $CO_2$ emissions costs than the non-renewable energy sectors. This is primarily due to the greater $CO_2$ emissions costs associated with the fuelwood and vegetable charcoal sectors. The hypothesis is not accepted.

Table 41. Energy sector carbon dioxide costs (Cr$).

| Energy Sub-Sectors | $CO_2$ Cost |
|---|---|
| Other | 2223 |
| Bagasse | 2303 |
| Ethanol-M | 2431 |
| Ethanol-T | 2442 |
| Oil | 2757 |
| Gas | 3027 |
| Kerosene | 3030 |
| Gasoline | 3242 |
| Electricity | 3251 |
| Coal | 3279 |
| Fuelwood | 3863 |
| Vegetable Charcoal | 3884 |

Source: Fixed Price Multiplier Matrix

E.1.2. SPA of $CO_2$ Costs and the Energy Sector

Table 42 presents the direct and indirect $CO_2$ costs associated with a 1000 Cr$ increase in the production of each energy sub-sector. The accounting multipliers for the $CO_2$ costs associated with energy production are very large. Therefore, an analysis of the global influence is important. Decomposing the global influence of an exogenous increase in the production of energy on $CO_2$ costs shows that the direct effects account for a high percentage of the global influence. With the exception of the other energy sub-sector, the direct effects account for 39% to 91% of the $CO_2$ costs associated with energy production. This finding suggests that the energy sector is directly responsible for the majority of the energy sector's total $CO_2$ costs.

The poles in Table 42 include: 27-coal, 28-bagasse, 29-kerosene, 30-oil, 31-gasoline, 32-modern ethanol, 33-traditional ethanol, 34-gas, 35-electricity, 36-fuelwood, 37-vegetable charcoal, 38-other, and 45-carbon dioxide.

Table 42. Global effects of energy production on carbon dioxide costs.

| | | Global | Direct | Path | Total | % of | Cum |
|---|---|---|---|---|---|---|---|
| Path | | Effect | Effect | Mult | Effect | Global | % |
| 27, 45 | | 3.413 | 0.576 | 4.386 | 2.527 | 74 | 74 |
| 28, 19, 45 | | 2.42 | 0.117 | 8.212 | 0.963 | 39.8 | 39.8 |
| 29, 45 | | 3.147 | 0.576 | 4.384 | 2.526 | 80.3 | 80.3 |
| 30, 45 | | 2.853 | 0.576 | 4.505 | 2.596 | 91 | 91 |
| 31, 45 | | 3.378 | 0.576 | 4.388 | 2.528 | 74.8 | 74.8 |
| 32, 19, 45 | | 2.55 | 0.229 | 4.675 | 1.069 | 41.9 | 41.9 |
| 33, 19, 45 | | 2.567 | 0.212 | 4.675 | 0.99 | 38.6 | 38.6 |
| 34, 45 | | 3.146 | 0.576 | 4.39 | 2.529 | 80.4 | 80.4 |
| 35, 45 | | 3.379 | 0.602 | 4.466 | 2.691 | 79.6 | 79.6 |
| 36, 45 | | 3.993 | 0.825 | 4.387 | 3.618 | 90.6 | 90.6 |
| 37, 45 | | 4.018 | 0.825 | 4.386 | 3.617 | 90 | 90 |
| 38, 24, 45 | | 2.365 | 0.096 | 5.02 | 0.481 | 20.4 | 20.4 |

## E.2.1 $CO_2$ Costs and Production Activities

Economic sectors account for approximately 79.5% of total $CO_2$ costs. Table 43 provides the $CO_2$ costs associated with the agriculture, manufacturing, and service sectors.

Table 43. $CO_2$ costs associated with select production activities (Cr$).

| | |
|---|---|
| K - Export Agriculture | 3655 |
| L - Traditional Agriculture | 2682 |
| K - Durable Consumer Goods | 3447 |
| L - Non-Dur. Consumer Goods | 3306 |
| K - Financial Services | 1653 |
| K - Public Services | 2189 |
| L - Private Services | 2080 |

Source: Fixed Price Multiplier Matrix.

Table 43 shows that the service sectors have the lowest $CO_2$ costs followed by the agriculture sector, and the manufacturing sector. The traditional agriculture sector (2682 Cr$) has lower $CO_2$ costs than the export agriculture sector (3655 Cr$). The non-durable consumer goods sector (3306 Cr$) has even lower $CO_2$ costs than the durable consumer goods sector (3447 Cr$). The financial services sector (1653 Cr$) has the lowest service sector $CO_2$ costs followed by the private services sector (2080 Cr$) and the public services sector (2189 Cr$).

Further inspection of the $CO_2$ costs and production activities reveals that the labor-intensive technologies have less $CO_2$ costs than the capital-intensive technologies. The traditional agriculture sector, the non-durable consumer goods sector, and the private services sector all have lower $CO_2$ costs than the export agriculture sector, the durable consumer goods sector, and the public services sector. It is not surprising that the service sectors have the lowest $CO_2$ costs while the manufacturing sector have the highest $CO_2$ costs.

E.2.2. SPA of $CO_2$ Costs and Production Activities

Table 44 includes the following poles: 18-export agriculture, 19-traditional agriculture, 23-durable consumer goods, 24-non-durable consumer goods, 40-financial/commercial services, 43-public services, 44-private services, and 45-carbon dioxide.

Table 44. Effects of select production activities on carbon dioxide costs.

| | | Global | Direct | Path | Total | % of | Cum |
|---|---|---|---|---|---|---|---|
| Path | | Effect | Effect | Mult | Effect | Global | % |
| 18, 45 | | 3.779 | 0.751 | 4.398 | 3.304 | 87.4 | 87.4 |
| 19, 45 | | 2.793 | 0.339 | 4.673 | 1.583 | 56.7 | 56.7 |
| 23, 45 | | 3.579 | 0.565 | 4.739 | 2.677 | 74.8 | 74.8 |
| 24, 45 | | 3.436 | 0.471 | 5.016 | 2.362 | 68.7 | 68.7 |
| 40, 45 | | 1.781 | 0.018 | 8.665 | 0.157 | 8.8 | 8.8 |
| 43, 45 | | 2.343 | 0.035 | 4.513 | 0.16 | 6.8 | 6.8 |
| 44, 18, 45 | | 2.209 | 0.001 | 4.855 | 0.005 | 0.2 | 0.2 |
| 44, 19, 45 | | | 0.004 | 5.147 | 0.019 | 0.8 | 1.1 |
| 44, 23, 45 | | | 0.006 | 5.226 | 0.032 | 1.5 | 2.6 |
| 44, 24, 45 | | | 0.073 | 5.481 | 0.399 | 18.1 | 20.6 |
| 44, 25, 45 | | | 0.031 | 6.939 | 0.217 | 9.8 | 30.5 |
| 44, 26, 45 | | | 0.014 | 5.752 | 0.08 | 3.6 | 34.1 |
| 44, 35, 45 | | | 0.004 | 4.929 | 0.018 | 0.8 | 34.9 |
| 44, 42, 45 | | | 0.003 | 4.994 | 0.017 | 0.7 | 35.6 |
| 44, 5, 15, 45 | | | 0.001 | 5.353 | 0.006 | 0.3 | 35.9 |
| 44, 5, 16, 45 | | | 0.005 | 5.101 | 0.026 | 1.2 | 37.1 |
| 44, 5, 17, 45 | | | 0.007 | 5.07 | 0.036 | 1.6 | 38.7 |
| 44, 6, 15, 45 | | | 0.002 | 5.374 | 0.012 | 0.6 | 39.2 |
| 44, 6, 16, 45 | | | 0.007 | 5.107 | 0.034 | 1.5 | 40.8 |
| 44, 6, 17, 45 | | | 0.005 | 5.126 | 0.023 | 1.1 | 41.8 |
| 44, 7, 14, 45 | | | 0.004 | 4.928 | 0.019 | 0.9 | 42.7 |
| 44, 8, 13, 45 | | | 0.014 | 5.459 | 0.076 | 3.4 | 46.1 |
| 44, 8, 14, 45 | | | 0.002 | 5.498 | 0.012 | 0.6 | 46.7 |
| 44, 8, 15, 45 | | | 0.009 | 5.503 | 0.051 | 2.3 | 49 |
| 44, 24, 18, 45 | | | 0.005 | 5.491 | 0.025 | 1.1 | 50.2 |
| 44, 24, 19, 45 | | | 0.003 | 5.801 | 0.018 | 0.8 | 51 |
| 44, 24, 25, 45 | | | 0.004 | 7.812 | 0.034 | 1.5 | 52.5 |
| 44, 26, 25, 45 | | | 0.006 | 8.195 | 0.045 | 2 | 54.5 |

Table 44 shows that the SPA of the direct and indirect effects of the global influence of the agriculture, manufacturing, and services sectors on the costs of $CO_2$ has mixed results. The direct effects of an exogenous increase in the agriculture and the manufacturing sectors on $CO_2$ costs are greater than the combined indirect effects. The global influence of an exogenous increase in the export agriculture on $CO_2$ is (3.779 Cr$) [path 18,45] and is significantly higher than that of the traditional agriculture (2.793 Cr$) [path 45]. The accounting multiplier for the durable consumer goods sector is (3.579 Cr$) [path 23,45] and is higher than the non-durable goods sector (3.436 Cr$) [path 24,45]. The accounting multipliers for the services sectors are as follows: financial/commercial services (1.781 Cr$) [path 40,45], public services (2.343 Cr$) [path 43.45], and private services (2.209 Cr$) [path 44,18,45]. Interestingly, the service sectors SPA results suggest that the indirect effects of the global influence of an exogenous increase in the production of financial/commercial services, public services, or private services on $CO_2$ costs are substantially higher than the direct effects. For example, path [44,18,45] indicates that the proportion of the direct effects of an exogenous increase on the private service sector is 0.2%, while the proportion of the indirect effects via the consumer non-durable goods is 18.1% [path 44,24,45] and the intermediate goods sector is 9.8% [path 44,25,45]. The service sectors have the lowest $CO_2$ costs compared to the agriculture, manufacturing, and energy sectors.

E.3.1 Energy Intensity of Production Activities

Fossil energy consumption is responsible for 70% to 90% of $CO_2$ emissions, the major greenhouse gas associated with global warming. Therefore, an analysis of the energy requirements of the different economic sectors is important to understand the linkage between production, energy consumption, and energy-related $CO_2$ emissions costs. In order to better understand the energy intensity of different production activities, the energy requirements of the agriculture, manufacturing, and services sectors were examined. The oil and electricity energy sub-sectors were selected as the conventional energy sources; the fuelwood sector was selected as the unconventional energy source. The purpose of this section is to determine whether or not the labor-intensive technologies consume more unconventional energy than the capital-intensive technologies; and to determine if capital-intensive technologies consume more conventional energy than the labor-intensive technologies.

Table 45 presents the conventional and unconventional energy consumption of the agriculture, manufacturing, and service sectors. The energy requirements of these sectors have ramifications for $CO_2$ emission costs due to the relationship between energy consumption and carbon emissions.

Table 45. Production activities consumption of select conventional and unconventional energy sources (Cr$).

| | Oil | Electricity | Fuelwood | Total |
|---|---|---|---|---|
| K - Export agriculture | 108 | 170 | 97 | 375 |
| L - Traditional agriculture | 85 | 131 | 76 | 292 |
| K - Durable consumer goods | 101 | 166 | 90 | 357 |
| L - Non-durable consumer goods | 98 | 160 | 89 | 347 |
| K - Financial/commercial services | 51 | 86 | 44 | 181 |
| K - Public services | 70 | 138 | 59 | 267 |
| L - Private services | 64 | 111 | 56 | 231 |

Source: Fixed price mulitplier matrix.

Table 45 indicates that in each case, the export agriculture, durable consumer goods, and the public services sectors consume more conventional and unconventional energy than the traditional agriculture, non-durable consumer goods, as well as the private services sector, and financial/commercial services sectors. The total energy requirement of the export agriculture sector is (375 Cr$) and (292 Cr$) for the traditional agriculture sector. The durable consumer goods sector spends (357 Cr$) compared to (347 Cr$) of the non-durable consumer goods sector. The public services sector had the greatest energy requirement, (267 Cr$); followed by the private services sector, (231 Cr$); and the financial services sector, (181 Cr$).

The total energy requirements of the capital-intensive technologies are greater than those of the labor-intensive technologies. Furthermore, the manufacturing sector consumes the most total energy, followed by the agriculture and service sectors. The manufacturing sector consumes the most fuelwood and oil. The service sectors consume the most electricity and the least oil and fuelwood.

E3.2. SPA of Energy Intensity and Production Activities

The accounting multipliers associated with an exogenous increase in the energy sector on $CO_2$ costs are so large that an understanding of the energy intensity of production activities is also very important. Therefore, an analysis was done on the SPA's global influence of an exogenous increase in agriculture, manufacturing, and service sectors on the following energy sub-sectors: oil, electricity, and fuelwood.

Table 46 includes the following poles: 30-oil, 35-electricity, 36-fuelwood, 18-export agriculture, 19-traditional agriculture, 23-durable consumer goods, 24-non-durable consumer goods, 43-public services, 44-private services.

Table 46 presents the SPA effects of an increase in the agriculture, manufacturing, and service sectors on their energy consumption. The global influence of an exogenous increase in the export agriculture sector on the oil sector is (.112 Cr$) [path 18,30] which is greater than an exogenous increase in the traditional agriculture sector on the oil sector (.089 Cr$) [path 19,30]. The global influence of an exogenous increase in the export agriculture sector on electricity is (.182 Cr$) [path 18,35]. This is greater than the exogenous increase in the traditional agriculture sector on the electricity sector (.143 Cr$) [path 19,35]. The global influence of an

Table 46. Select production activities effects on select energy sub-sectors.

| Path | | Global Effect | Direct Effect | Path Mult | Total Effect | % of Global | Cum % |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 18, 30 | | 0.112 | 0.003 | 1.344 | 0.003 | 3.1 | 3.1 |
| 19, 30 | | 0.089 | 0.006 | 1.339 | 0.008 | 8.6 | 8.6 |
| 23, 45, 30 | | 0.105 | 0.011 | 4.87 | 0.053 | 50.8 | 50.8 |
| 24, 45, 30 | | 0.102 | 0.009 | 5.155 | 0.047 | 46 | 46 |
| 43, 30 | | 0.074 | 0.002 | 1.164 | 0.002 | 2.4 | 2.4 |
| 44, 24, 45, 30 | | 0.067 | 0.001 | 5.632 | 0.008 | 11.8 | 11.8 |
| 18, 35 | | 0.182 | 0.002 | 1.409 | 0.003 | 1.5 | 1.5 |
| 19, 35 | | 0.143 | 0.004 | 1.408 | 0.005 | 3.5 | 3.5 |
| 23, 35 | | 0.178 | 0.004 | 1.582 | 0.007 | 3.9 | 3.9 |
| 24, 35 | | 0.172 | 0.004 | 2.113 | 0.008 | 4.7 | 4.7 |
| 43, 35 | | 0.151 | 0.025 | 1.231 | 0.03 | 20.1 | 20.1 |
| 44, 35 | | 0.123 | 0.006 | 1.394 | 0.008 | 6.7 | 6.7 |
| 18, 36 | | 0.104 | 0.003 | 1.334 | 0.003 | 3.3 | 3.3 |
| 19, 36 | | 0.084 | 0.005 | 1.33 | 0.007 | 8.2 | 8.2 |
| 23, 45, 36 | | 0.096 | 0.013 | 4.742 | 0.063 | 65.6 | 65.6 |
| 24, 36 | | 0.096 | 0.002 | 2.03 | 0.003 | 3.4 | 3.4 |
| 44, 24, 45, 36 | | 0.062 | 0.002 | 5.484 | 0.009 | 15.1 | 15.1 |

exogenous increase in the export agriculture sector on the fuelwood sector is (.104 Cr$) [path 18,36] and is greater than the global effect of an exogenous increase in the traditional agriculture sector on fuelwood sector (.084 Cr$) [path 19,36]. This suggests that for the agriculture sector, the modern technology has a higher energy intensity than the traditional technology.

The global influence of the consumer durable goods sector on oil is (.105 Cr$) [path 23,45,30] and electricity (.178 Cr$) [path 23,35]. These are greater than the global influence of an increase in the consumer non-durable goods sector on oil (.102 Cr$) [path 24,45,30] and electricity (.172 Cr$) [path 23,45]. The global influence of an exogenous increase in either the consumer durable goods sector or consumer non-durable goods sector results in an increase in the fuelwood sector of (.096 Cr$) [path 23,45,36 and path 24,36]. This suggests that the consumer durable goods sector has a little higher energy intensity than the non-durable consumer goods sector.

The public and private service sectors utilize oil, electricity, and fuelwood. The global influence of an exogenous increase in the public services sector on oil is (.074 Cr$) [path 43,30] and is greater than the private services sector (.067 Cr$) [path 44,30]. The global influence of an exogenous increase in the public services sector on the electricity sector is (.151 Cr$) [path 43,35] which is greater than the global influence of an exogenous increase in the private services sector on the electricity sector (.123 Cr$) [path 44,35]. Only the public services sector utilizes fuelwood (.062 Cr$) [path 44,24,45,36]. The public services sector consumes more energy than the private services sector.

These findings suggest that the relatively labor-intensive technologies have lower energy intensities than the comparative capital-intensive technologies. The traditional agriculture sector is more energy efficient than the export agriculture sector. The consumer non-durable goods sector is more efficient than the durable consumer goods sector. Finally, the financial/commercial services sector is more energy efficient than the private services sector which is more efficient than the public services sector. Comparing the economic sectors, demonstrates that the service industry is the most energy efficient, followed by agriculture, and manufacturing.

Hypothesis five is accepted because the $CO_2$ costs associated with most labor-intensive technologies are lower than the comparable capital-intensive technologies. $CO_2$ costs of the ethanol sectors are lower than those of the gasoline sector. The traditional ethanol sector has slightly higher $CO_2$ costs than the modern ethanol sector. This is due to the traditional ethanol sector's indirect effects. The renewable energy sectors have higher $CO_2$ costs than the non-renewable energy sectors because of the greater $CO_2$ costs associated with the fuelwood and vegetable charcoal sectors.

The labor-intensive technologies of the agriculture and manufacturing sectors have lower $CO_2$ costs than the comparative capital-intensive technologies; however, the capital-intensive technique of the service sectors has lower $CO_2$ costs than its comparative labor-intensive technique. An increase in the production of export agriculture sector has higher $CO_2$ costs higher than the traditional agriculture sector. The durable consumer goods sector has significantly higher $CO_2$ costs than the non-durable goods sector. The private services sector has greater $CO_2$ costs than the public services sector; however, the financial/commercial services sector has the lowest $CO_2$ costs. The services sectors have the lowest $CO_2$ costs followed by the agriculture, manufacturing, and energy sectors.

The energy requirements of the agriculture, manufacturing, and services sectors were examined to better understand the linkage between production, energy consumption, and energy-related $CO_2$ emissions costs. The oil and electricity energy sub-sectors were selected as the conventional energy sources; whereas, the fuelwood sector was selected as the unconventional energy source. The labor-intensive technologies consume less unconventional and conventional energy than the capital-intensive technologies. The traditional agriculture sector is more energy efficient than the export agriculture sector. The consumer non-durable goods sector is more efficient than the consumer durable goods sector. The financial/commercial services sector is more energy efficient than either the private or public services sectors. The labor-intensive technologies of the agriculture, manufacturing, and service sectors are more energy efficient than the comparative capital-intensive technologies.

## CONCLUSION

Hypothesis one examined the effect of technology choice on employment. First, the two ethanol sectors were analyzed to determine which production technique provides the most employment. It was found that the employment multipliers for the modern ethanol sector were very slightly higher than the traditional ethanol sector (14.49 vs. 14.38) and that both ethanol sectors were higher than the gasoline sector (11.01). The ethanol sectors employ nearly three times more people than the gasoline sector.

The employment multipliers for the agriculture, manufacturing, and service sectors were also computed. The export agriculture sector employed more people than the traditional agriculture sector. The employment multiplier for the consumer non-durable goods sector was greater than that of the consumer durable goods sector. Finally, the private sector generates the most employment followed by the public service sector and the financial/commercial sector. The employment multipliers were the highest for the agriculture sectors followed by the manufacturing and service sectors. Interestingly, the labor-intensive technologies for the manufacturing and service sectors generated more employment than the comparative capital-intensive technologies. The capital-intensive techniques employed more people in the agriculture and ethanol sectors. This is due to the export agriculture sector's greater direct and indirect employment effect than the traditional agriculture sector. The modern ethanol sector had more linkages to traditional agriculture and the transportation sectors than the traditional ethanol sector.

Hypothesis two investigated the effect of technology choice on factor income. It examined whether a labor-intensive technology generated more labor income than the capital-intensive technology. Several production activities were analyzed. A comparison of the two ethanol and gasoline sectors demonstrated that the ethanol sectors provided the most labor and capital income. Furthermore, the traditional ethanol sector contributed more combined labor and capital income than the modern ethanol sector. However, the gasoline sector generated more labor income than the modern ethanol sector, but less than that of the traditional ethanol sector.

A comparison of the agriculture and manufacturing sectors revealed that the labor-intensive technology raised more labor and capital income than the capital-intensive technology. The traditional agriculture sector provided more total factor income than the export agriculture sector. Traditional agriculture produced more agriculture labor and agriculture capital income than the export agriculture sector. However, the export agriculture sector contributed more non-agriculture labor and non-agriculture capital income than the traditional agriculture sector. The consumer non-durable sector generated greater factor income than the consumer durable goods sector. Interestingly, the consumer non-durable goods sector provided more capital income and slightly less labor income than the durable consumer goods sector.

The capital-intensive technique of the service sectors generated more factor income than the labor-intensive technique. The public services sector produced greater total factor income than the financial services sector and the private sector. The public services sector provided the most labor income and the least capital income of the service sectors. The financial services sector contributed the most capital income and the least total factor income of the service sectors. The capital-intensive technique of the service sector was the only case of a capital-intensive technology which netted more factor income than a labor-intensive technology.

While the labor-intensive technologies of the agriculture and manufacturing sectors provide more total combined labor and capital factor income, an analysis of the agriculture and non-agriculture labor income showed interesting results. The labor-intensive technologies generated the most agriculture labor income in each of the agriculture, manufacturing, and service sectors. The capital-intensive technologies produced the most non-agriculture labor income in the agriculture and manufacturing sectors. The agriculture and manufacturing labor-intensive technologies generated more capital income than the capital-intensive technologies. This was due to the high return to agriculture capital income.

SPA was applied to observe the effects of an exogenous increase in the production of additional activities on the labor income of unskilled agriculture workers and unskilled non-agriculture workers. SPA demonstrated that the traditional and modern ethanol sectors produced the same income to unskilled agriculture workers. However, the traditional ethanol sector provided significantly more income to unskilled non-agriculture workers than the modern ethanol sector.

SPA revealed that the global influence of the traditional agriculture sector raised more income to unskilled agriculture workers than the export agriculture sector. However the export agriculture sector generated more income to unskilled non-agriculture workers than the traditional agriculture sector. The consumer non-durable goods sector returned more income to unskilled agriculture labor than the consumer durable goods sector; whereas, the durable consumer goods sector provided more income to unskilled non-agriculture labor than the non-durable consumer goods sector. The public and private service sectors contributed more income to unskilled agriculture labor than the financial services sector. The public services sector provided the most income to unskilled non-agriculture income followed by the private services sector and the financial services sector. SPA also illustrated that the proportion of indirect effects were more important than the direct effects. In the manufacturing and services sectors, the indirect effects on unskilled workers income were larger than the direct effects.

The labor intensive technologies in the agriculture, manufacturing, and service sectors produced more labor income to unskilled agriculture workers than the comparative capital-intensive technology. However, the capital-intensive technologies of these sectors raised more labor income to unskilled non-agriculture workers. This suggests that labor-intensive technologies contribute more to rural unskilled workers and that capital-intensive technologies provide more to urban unskilled workers.

Hypothesis three investigated the effect of technology choice on household income. It was found that the traditional ethanol sector provided the most household income, followed by the gasoline sector and modern ethanol sector. Two findings were surprising. First, the modern ethanol sector provided slightly more income to all rural households and urban managers than the traditional ethanol sector. Second, the traditional ethanol sector contributed more to household incomes of urban small producers, urban organized labor, and urban non-organized labor than the modern ethanol sector. The major reason that the modern ethanol sector generated more income to rural households, is due to the greater agriculture capital that the traditional agriculture sector generates, which is further distributed to the rural households. The modern ethanol sector purchased more from the traditional agriculture sector which was distributed to agricultural factors of production.

Urban small producers, urban organized workers, and urban non-organized workers households, received more income from the traditional ethanol sector than from the modern ethanol sector. SPA indicated that unskilled non-agriculture labor received three times more income, and that skilled non-agriculture labor received two times more income from the traditional ethanol sector than from the modern ethanol sector. This result was due to the higher labor costs associated with the traditional ethanol sector.

Comparing the household income of the production activities revealed that the agriculture and manufacturing labor-intensive technologies generated more total household income than the comparative capital-intensive technologies. The traditional agriculture sector provided more income to rural households and to rural households in poverty than the export agriculture sector. Conversely, the export agriculture sector contributed more income to urban households and more income to urban households in poverty. The non-durable consumer goods sector produced more income to rural households and rural households in poverty. The durable consumer goods sector raised more urban household income and more income to urban households in poverty. Examination of the service sectors indicated that the public services sector returned the most total household income, the most total urban household income, and the most income to urban households in poverty. The private services sector provided the most income to rural households of the service sectors. The public and private service sectors provided the same income to rural households in poverty, and was greater than the financial services sector's contribution to rural households in poverty.

The economic sector which raised the most household income was the service sector followed by the agriculture and manufacturing sectors. The labor-intensive technologies generated more total household income than the comparative capital-intensive technologies in two of the three economic sectors: agriculture and manufacturing. Interestingly, in each of the agriculture, manufacturing, and service sectors, the labor-intensive technologies generated more income to rural households than the capital-intensive technologies. The capital-intensive service sector provided more household income than the comparative labor-intensive service sector technology.

SPA of an exogenous increase in the production of agriculture, manufacturing, and services sectors on the poorest rural and urban household incomes (i.e., the rural workers/tenant farmers household and urban non-organized workers household) was also done. SPA indicated that an exogenous increase in the production of traditional agriculture or consumer non-durable goods generated more household income for rural workers/tenant farmers than the export agriculture sector or the consumer durable goods sector. The labor-intensive sectors of the agriculture, and manufacturing industries contributed more income to rural households in poverty than the capital-intensive sectors of the agriculture and manufacturing industries.

Comparing export and traditional agriculture indicated that the export agriculture sector generated more urban non-organized workers household income than the traditional agriculture sector. The non-durable consumer goods sector provided slightly more household income to the urban non-organized workers than the durable consumer goods sector. Further analysis of the global influence for the manufacturing sectors revealed that the indirect effects of the non-durable consumer goods sector were two times greater than the indirect effects of the durable consumer goods sector on the urban household income of non-organized labor. This suggests that the non-durable consumer goods sector had significantly more linkages with sectors affecting the urban household income of non-organized labor than the consumer durable goods sector. Analysis of the service sectors indicated that the public services sector generated the most urban household income to non-organized labor, followed by private services, and financial/commercial services. In addition, the capital-intensive technologies in each of the economic sectors studied generated more income to urban households in poverty.

Hypothesis four looked more closely at the energy sector. It examined the employment, household income, and factor income effects of the twelve energy sub-sectors. Ranking the employment multipliers of the energy sectors from the highest to the lowest gave the following order: fuelwood and vegetable charcoal, modern ethanol, traditional ethanol and bagasse, coal, electricity and other, kerosene, and oil. A few of the non-renewable energy sectors had larger direct employment effects than the renewable energy sector; however, the indirect effects of the renewable energy sectors were greater than those of the non-renewable energy sector. Thus, renewable energy sectors provided more employment than the non-renewable energy sectors and were relatively more labor-intensive than the non-renewable energy sectors.

The energy sub-sectors affected agriculture and non-agriculture factor income differently. Unskilled agriculture labor received the most income from the ethanol sectors followed by the bagasse and vegetable charcoal sectors. Skilled agriculture labor also received the most income from the modern ethanol sector, followed by the traditional ethanol sector and bagasse sector. Agriculture managers obtained the most income from the modern ethanol sector followed by the traditional ethanol sector and bagasse sector. Agriculture capital received the most return from the modern ethanol sector followed by the traditional ethanol and bagasse sectors. The modern and traditional ethanol sectors provided the greatest income to both agriculture labor and agriculture capital of all the energy sub-sectors. The renewable energy sectors raised more factor income than the non-renewable energy sectors. Renewable energy also provided more agriculture labor and agriculture capital income as well as more non-agriculture labor and non-agriculture capital income.

The energy sub-sectors were also analyzed for their effects on non-agriculture factors of production. Unskilled non-agriculture labor received the most income from the traditional ethanol sector, followed by the kerosene sector, vegetable charcoal sector, and the gasoline and coal sectors. Skilled non-agriculture labor received the most income from the gasoline sector, followed by the electricity and vegetable charcoal sectors, and the fuelwood sector. Non-agriculture managers gained the most income from the gasoline and coal sectors, followed by the fuelwood and vegetable charcoal sectors, and the modern ethanol sector. Non-agriculture capital received the highest return from the gasoline sector, followed by the coal sector, electricity sector, and the fuelwood sector. Interestingly, analysis of the non-agriculture factor income accounts found that the gasoline sector provided the most income to non-agriculture capital, non-agriculture managers, and skilled non-agriculture labor.

The energy sector's impact on household income was interesting. The traditional ethanol sector generated the most household income followed by the vegetable charcoal sector, gasoline sector, modern ethanol sector, fuelwood sector, coal sector, bagasse sector, electricity sector, gas sector, kerosene sector, other sector, and oil sector.

Renewable energy provided more rural and urban household income than non-renewable energy. Rural households gained almost twice as much household income from the renewable energy sectors than from the non-renewable energy sector. Urban households on the other hand receive only slightly more from the renewable energy than from the non-renewable energy sectors. For households in poverty renewables raised rural incomes almost one and a half times more than non-renewables; urban incomes increased slightly more by renewable energy than by non-renewable energy sectors. Renewable energy significantly and positively contributed to household income in Brazil, especially rural and urban households in poverty.

Hypothesis five considered the $CO_2$ costs associated with technology choice. Again the ethanol and gasoline sectors were compared. The analysis found that the traditional ethanol sector had slightly higher $CO_2$ costs than the modern ethanol sector. This is due to the traditional ethanol sector's greater indirect linkages to the traditional agriculture sector and transportation sector. The gasoline sector had greater $CO_2$ costs than the ethanol sectors. Ranking the $CO_2$ costs of the energy sub-sectors from the lowest to the highest gave the following list: other, bagasse, modern ethanol, traditional ethanol, oil, gas, kerosene, gasoline, electricity, coal, fuelwood, and vegetable charcoal. The renewable energy sectors had higher $CO_2$ costs than the non-renewable energy sectors, because of the greater $CO_2$ emissions costs associated with the fuelwood and vegetable charcoal sectors.

An increase in the production of export agriculture sector had higher $CO_2$ costs than those of the traditional agriculture sector. The durable consumer goods sector had significantly higher $CO_2$ costs than the non-durable goods sector. The private services sector had greater $CO_2$ costs than the public services sector. However, the financial/commercial services sector had the lowest $CO_2$ costs. Interestingly, SPA of the service sectors revealed that the indirect effects of the global influence of an exogenous increase in the production of the services sectors on $CO_2$ costs were substantially greater than the direct effects. The service sectors had the lowest $CO_2$ costs compared to the agriculture, manufacturing, and the energy sectors. Interestingly the labor-intensive technologies of the agriculture and manufacturing sectors had lower $CO_2$ costs than the comparative capital-intensive technologies. However, the capital-intensive technique of the service industry's had lower $CO_2$ costs than the labor-intensive technique.

An additional analysis was done because fossil energy consumption is responsible for 70% to 90% of $CO_2$ emissions, the major greenhouse gas associated with global warming. Therefore, energy intensities of the different economic sectors were analyzed to better understand the linkage between production, energy consumption, and energy-related $CO_2$ emissions costs. The energy requirements of the agriculture, manufacturing, and services sectors were examined. The oil and electricity energy sub-sectors were selected as the conventional energy sources; the fuelwood sector was selected as the unconventional energy source. In each sector studied, it was determined that the labor-intensive technologies consume less unconventional and conventional energy than the comparative capital-intensive technologies. The traditional agriculture sector was more energy efficient than the export agriculture sector. The consumer non-durable goods sector was more efficient than the consumer durable goods sector. The financial/commercial services sector was more energy efficient than either the private or public services sectors. The labor-intensive technologies of the agriculture, manufacturing, and service sectors were more energy efficient than the comparative capital-intensive technologies.

It is clear from the analyses performed that labor-intensive technologies and the ethanol industry contribute significantly to Brazil's socioeconomic development in terms of employment generation. They also help in alleviating regional factor and household income disparities and environmental costs associated with carbon dioxide.

# CHAPTER EIGHT

# CONCLUSION

The overall objective of this research was to assess the extent to which technology choice has affected socioeconomic development. The research initially focused on Brazil's fuel ethanol program because it is the world's most extensive alternative fuel program. It was intriguing because the ethanol program has important implications for energy, environmental, and development planning. In addition, it was not the result of a technology transfer, but rather the effort of a newly industrialized country to develop an indigenous and renewable gasoline substitute. The research used the social accounting matrix modeling methodology which permitted an expansion of the analysis to include comparative technologies in the production of energy, agriculture, manufacturing, and service sectors. These extensions allowed a more comprehensive assessment of the effects of technology choice on employment, income distribution, and the environment.

This research measured the direct and indirect impacts of the energy, agriculture, manufacturing, and service sectors on Brazil's socioeconomic development. Two ethanol production technologies and the gasoline sector were compared. In addition, labor-intensive and capital-intensive technologies were also analyzed in the production of agriculture, energy, manufacturing, and services sectors to capture any differences due to technology choice. Growth in the economic sectors was examined to determine its effects on employment, labor and capital income, household income, carbon dioxide costs, and energy intensity. Because poverty alleviation was of concern, additional analyses were done. The income effects resulting from growth in the economic sectors to unskilled agriculture labor, unskilled non-agriculture labor, and rural and urban households in poverty were measured. The research findings suggests that significant differences exist in the employment, labor and household income, environmental and energy effects due to technology choice. Section one presents the key findings. Section two discusses the contributions to the literature. Section three presents the policy implications of this research.

## SECTION ONE: MAJOR RESEARCH FINDINGS

The employment, factor income, household income, environment, and energy intensity research findings are summarized in Table 47 and Table 48. Table 47 presents the economic sector results. Table 48 provides the energy sector results. The key findings are divided into three sections: the ethanol/gasoline comparison, energy sector comparisons, and economic sector comparisons.

Table 47. Summary of Economic Sector Effects (Cr$)

| | Gasoline | Ethanol Modern K | Ethanol Traditional L | Ag Export K | Ag Traditional L | Cons.Goods Durable K | Cons.Goods Non-Durable L | Financial Services K | Public Services K | Private Services L |
|---|---|---|---|---|---|---|---|---|---|---|
| Employment | 11.01 | 14.49 | 14.38 | 19.2 | 16.43 | 12.03 | 12.87 | 8.48 | 10.97 | 12.89 |
| | | | | | | | | | | |
| Factor Income | 1562 | 1639 | 1687 | 1502 | 1620 | 1493 | 1543 | 1603 | 1828 | 1563 |
| Capital Income | 1069 | 1185 | 1165 | 1069 | 1202 | 1005 | 1066 | 1180 | 933 | 985 |
| Labor Income | 493 | 453 | 522 | 433 | 418 | 488 | 478 | 423 | 895 | 578 |
| Agriculture Labor Income | 25 | 65 | 63 | 46 | 88 | 27 | 44 | 15 | 21 | 22 |
| Non-Ag Labor Income | 468 | 388 | 460 | 387 | 329 | 462 | 433 | 408 | 874 | 556 |
| Ag. Unskilled Labor Income | 6 | 12 | 12 | 12 | 16 | 6 | 10 | 3 | 5 | 5 |
| Non-Ag. Unskilled Labor Income | 173 | 148 | 202 | 151 | 129 | 180 | 167 | 155 | 374 | 224 |
| Household Income | | | | | | | | | | |
| Total Household Income | 1732 | 1723 | 1775 | 1721 | 1734 | 1694 | 1723 | 1594 | 1912 | 1628 |
| Total Rural Income | 176 | 453 | 432 | 367 | 615 | 187 | 257 | 100 | 139 | 141 |
| Total Urban Income | 1556 | 1270 | 1343 | 1355 | 1119 | 1506 | 1466 | 1495 | 1773 | 1487 |
| Rural HH in Poverty | 31 | 74 | 71 | 58 | 100 | 33 | 47 | 18 | 25 | 25 |
| Urban HH in Poverty | 472 | 376 | 449 | 416 | 342 | 466 | 445 | 382 | 730 | 500 |
| | | | | | | | | | | |
| Environment | | | | | | | | | | |
| CO2 emission costs | 3242 | 2431 | 2442 | 3655 | 2682 | 3447 | 3306 | 1653 | 2189 | 2080 |
| Total Energy Consumption | 1469 | 1372 | 1374 | 525 | 406 | 502 | 487 | 258 | 367 | |
| Total Fossil-Fuel Energy | 1166 | 131 | 132 | 185 | 143 | 175 | 170 | 90 | 121 | |
| Electricity | 153 | 121 | 122 | 170 | 131 | 166 | 160 | 86 | 138 | |
| Total Biomass | 146 | 1116 | 1117 | 165 | 128 | 156 | 153 | 79 | 105 | |
| Other Energy | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | |
| Total Non-Renewable | 1170 | 134 | 136 | 189 | 147 | 179 | 174 | 92 | 124 | |
| Total Renewable | 299 | 1237 | 1239 | 335 | 259 | 322 | 314 | 166 | 243 | |

Table 48. Summary of Energy Sector Effects (Cr$).

| | Coal | Bagasse | Kerosene | Oil | Gasoline | Ethanol-M | Ethanol-T | Gas | Electricity | Fuelwood | Veg. Char | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | K | L | K | K | K | L | L | K | L | L | L | K | |
| Employment | 11.77 | 14.27 | 9.65 | 8.53 | 11.01 | 14.49 | 14.38 | 10.25 | 11.39 | 20.09 | 20.20 | 10.64 | 157 |
| | | | | | | | | | | | | | 0 |
| Factor Income | | | | | | | | | | | | | 0 |
| Total Factor Income | 1533 | 1590 | 1315 | 1072 | 1562 | 1639 | 1687 | 1357 | 1464 | 1477 | 1492 | 1368 | 17556 |
| Total Capital Income | 1063 | 1139 | 850 | 754 | 1069 | 1185 | 1165 | 925 | 1008 | 1004 | 1004 | 936 | 12102 |
| Total Labor Income | 471 | 450 | 464 | 319 | 493 | 453 | 522 | 433 | 457 | 473 | 487 | 432 | 5454 |
| Total Ag Labor | 26 | 60 | 23 | 21 | 25 | 65 | 63 | 23 | 25 | 30 | 31 | 22 | 413 |
| Total Non-Ag. Labor | 445 | 391 | 441 | 298 | 468 | 388 | 460 | 409 | 432 | 444 | 456 | 409 | 5041 |
| Ag. Unskilled Labor | 6 | 11 | 5 | 5 | 6 | 12 | 12 | 5 | 5 | 6 | 7 | 5 | 84 |
| Non-Ag. Unskilled Labor | 173 | 158 | 180 | 115 | 173 | 148 | 202 | 155 | 158 | 168 | 179 | 151 | 1958 |
| | | | | | | | | | | | | | |
| Household Income | | | | | | | | | | | | | |
| Total HH Income | 1708 | 1666 | 1496 | 1240 | 1732 | 1723 | 1775 | 1527 | 1644 | 1720 | 1737 | 1454 | 19422 |
| Total Rural Income | 178 | 414 | 163 | 146 | 176 | 453 | 432 | 163 | 175 | 211 | 219 | 142 | 2872 |
| Total Urban Income | 1529 | 1253 | 1332 | 1094 | 1556 | 1270 | 1343 | 1364 | 1469 | 1510 | 1518 | 1312 | 16550 |
| Rural HH in Poverty | 31 | 68 | 29 | 25 | 31 | 74 | 71 | 29 | 31 | 37 | 38 | 26 | 489 |
| Urban HH in Poverty | 454 | 385 | 444 | 320 | 472 | 376 | 449 | 418 | 443 | 468 | 480 | 394 | 5103 |
| | | | | | | | | | | | | | 0 |
| Environment | | | | | | | | | | | | | 0 |
| CO2 | 3279 | 2303 | 3030 | 2757 | 3242 | 2431 | 2442 | 3027 | 3251 | 3863 | 3884 | 2223 | 35733 |
| Total Energy Consumption | 1474 | 2111 | 1434 | 1417 | 1469 | 1372 | 1374 | 1434 | 1481 | 1548 | 1551 | 1347 | 18011 |
| Total Fossil-Fuel Energy | 1167 | 125 | 1153 | 1165 | 1166 | 131 | 132 | 1153 | 166 | 194 | 194 | 122 | 6867 |
| Electricity | 154 | 115 | 141 | 127 | 153 | 121 | 122 | 141 | 1165 | 178 | 179 | 113 | 2710 |
| Total Biomass Energy | 148 | 1867 | 136 | 122 | 146 | 1116 | 1117 | 136 | 146 | 1172 | 1173 | 108 | 7387 |
| Other Energy | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 4 | 4 | 5 | 5 | 1004 | 1047 |

A. Employment Findings

Table 49 shows that the labor-intensive technologies generated more total employment than the capital-intensive technologies in the energy, manufacturing, and service sectors. There was one exception, the capital-intensive technology of the agriculture sector generated more employment that the labor-intensive technology. Comparing these sectors showed that the employment multipliers were highest for energy, followed by the agriculture, manufacturing and service sectors.

Table 49. Labor and capital intensive employment multipliers

| Labor-Intensive | | | Capital-Intensive | |
|---|---|---|---|---|
| | | | | |
| Traditional Ag | 16.43 | | Export Ag | 19.2 |
| Non Dur Consumer | 12.87 | | Dur. Consumer | 12.03 |
| Private Services | 12.89 | | Financial Services | 8.48 |
| | | | Public Services | 10.97 |
| Energy | | | Energy | |
| Bagasse | 14.27 | | Coal | 11.77 |
| Ethanol-T | 14.38 | | Gasoline | 11.01 |
| Ethanol-M | 14.49 | | Kerosene | 9.65 |
| Electricity | 11.39 | | Oil | 8.53 |
| Fuelwood | 20.09 | | Gas | 10.25 |
| Veg. Charcoal | 20.2 | | Other | 10.64 |

*A.1. Total employment was not significantly different between the labor-intensive technique and the capital-intensive technique in ethanol production.*

Total employment was greater for the ethanol sectors than for the gasoline sector. The ethanol employment multipliers were 14.49 for the modern ethanol sector, 14.38 for the traditional ethanol sector, and 11.01 for the gasoline sector. Total employment for each of the ethanol sectors was not significantly different, even though direct employment in the traditional ethanol sector was about three times greater than the modern ethanol sector. The indirect employment effects accounted for the differences between the modern and traditional ethanol sectors. The modern ethanol sector's linkage to the traditional agriculture sector resulted in slightly higher employment for the modern ethanol sector than for the traditional ethanol sector.

*A.2. The labor-intensive technologies of the energy sector provided significantly more employment than the capital-intensive technologies of the energy sector.*

Employment multipliers of the labor-intensive energy technologies (modern ethanol-14.49, traditional ethanol-14.38, bagasse-14.27, electricity-11.39, fuelwood-20.09, and vegetable charcoal-20.20) were significantly higher than those of the capital-intensive energy technologies (coal-11.77, gasoline-11.0, kerosene-9.65, oil-8.53, gas-10.25, and, other-10.64). While the direct employment effects of some of non-renewable energy sectors were larger than the direct employment effects of some renewable energy sectors, the total employment associated with the renewable energy sectors were larger than the non-renewable energy sectors because of the indirect effects. For example, the coal sector's direct employment was .96 and total employment was 12; bagasse's direct employment was .72 and total employment was 14. Indirect employment effects of the renewable energy sectors accounted for renewable energy's greater employment than those of the non-renewable energy sectors. The renewable energy technologies which were relatively labor intensive had higher employment than the capital-intensive energy technologies.

*A.3. The labor-intensive technologies of the manufacturing and service sectors generated more employment than the comparative capital-intensive technologies. Agriculture's capital-intensive technology provided more employment than the labor-intensive technology.*

The employment multipliers of the consumer non-durable goods sector was 12.87 and 12.89 for the private services sector. They were higher than the durable goods sector 12.03 and the service sectors (public services, 10.97 and the financial/commercial services sectors, 8.48). There was one exception: the export agriculture sector 19.20, generated more total employment than the traditional agriculture sector, 16.43.

B. Factor Income Findings

Table 50 provides the factor income of the comparative labor and capital intensive technologies. The labor intensive technologies of the agriculture, manufacturing, and energy sectors produced more total labor and capital income, more agriculture labor income, and more labor income to unskilled agriculture workers than the comparative capital-intensive technologies. However, the capital-intensive technologies of the agriculture, manufacturing, and energy sectors raised more non-agriculture labor income and more labor income to unskilled non-agriculture workers than the comparative labor-intensive technologies. The capital-intensive technology of the service sector was the only case of a capital-intensive technology providing more factor income than the labor-intensive technology.

Table 50. Labor and capital intensive sectors and factor income (Cr$).

| | Factor Income | Capital Income | Labor Income | Ag Labor | Non-Ag. Labor | Unskilled Ag. Labor | Unskilled Non-Ag. Labor |
|---|---|---|---|---|---|---|---|
| LABOR-INT. TECHNOLOGIES | | | | | | | |
| Traditional Ag | 1620 | 1202 | 418 | 88 | 329 | 16 | 129 |
| Con Non-Durable Goods | 1543 | 1066 | 478 | 44 | 433 | 10 | 167 |
| Private Services | 1563 | 985 | 578 | 22 | 556 | 5 | 224 |
| | | | | | | | |
| Energy Sector | | | | | | | |
| Bagasse | 1590 | 1139 | 450 | 60 | 391 | 11 | 158 |
| Ethanol-M | 1639 | 1185 | 453 | 65 | 388 | 12 | 148 |
| Ethanol-T | 1687 | 1165 | 522 | 63 | 460 | 12 | 202 |
| Electricity | 1464 | 1008 | 457 | 25 | 432 | 5 | 158 |
| Fuelwood | 1477 | 1004 | 473 | 30 | 444 | 6 | 168 |
| Vegetable Charcoal | 1492 | 1004 | 487 | 31 | 456 | 7 | 179 |
| Total Labor-Int. Energy | 9349 | 6505 | 2843 | 273 | 2570 | 53 | 1013 |
| | | | | | | | |
| CAPITAL-INT. TECHNOLOGIES | | | | | | | |
| Export Ag | 1502 | 1069 | 433 | 46 | 387 | 12 | 151 |
| Con Durable Goods | 1493 | 1005 | 488 | 27 | 462 | 6 | 180 |
| Financial Services | 1603 | 1180 | 423 | 15 | 408 | 3 | 155 |
| Public Services | 1828 | 933 | 895 | 21 | 874 | 5 | 374 |
| | | | | | | | |
| Energy Sector | | | | | | | |
| Coal | 1533 | 1063 | 471 | 26 | 445 | 6 | 173 |
| Kerosene | 1315 | 850 | 464 | 23 | 441 | 5 | 180 |
| Oil | 1072 | 754 | 319 | 21 | 298 | 5 | 115 |
| Gasoline | 1562 | 1069 | 493 | 25 | 468 | 6 | 173 |
| Gas | 1357 | 925 | 433 | 23 | 409 | 5 | 155 |
| Other | 1368 | 936 | 432 | 22 | 409 | 5 | 151 |
| Total Capital-Int. Energy | 8208 | 5597 | 2611 | 140 | 2471 | 31 | 945 |

B.1.1 *Ethanol's labor-intensive technology generated more total labor income than ethanol's capital-intensive technology; however, ethanol's capital-intensive technology generated more capital income than ethanol's labor-intensive technology.*

Total factor income for the modern ethanol sector was (1639 Cr$), (1687 Cr$) for the traditional ethanol sector, and (1562 Cr$) for the gasoline sector. Total labor income was (453 Cr$) for the modern ethanol technology, (522 Cr$) for the traditional ethanol technology, and (493 Cr$) for the gasoline sector. The ethanol sectors generated more total labor income than the gasoline sector. Furthermore, the traditional ethanol sector provided greater labor income (522 Cr$) than the modern ethanol sector (453 Cr$). The capital income of the ethanol sectors was more than the capital income of the gasoline sector. The modern ethanol sector generated the most capital income (1185 Cr$), followed by the traditional ethanol sector (1165 Cr$), and the gasoline sector (1069 Cr$).

B.1.2. *Unskilled agriculture labor benefited equally from the modern ethanol sector and the traditional ethanol sector. Unskilled non-agriculture labor benefited significantly more from the traditional ethanol sector than the modern ethanol sector.*

Unskilled agriculture labor received (12 Cr$) each from the modern and traditional ethanol. Unskilled non-agriculture labor received (202 Cr$) from the traditional ethanol technology and (148 Cr$) from the modern ethanol technology. Labor costs were higher for the traditional ethanol sector than for the modern ethanol sector.

The policy implication of this analysis is that unskilled non-agriculture labor benefits significantly more from the traditional ethanol sector than the modern ethanol sector.

B.2.1. *The labor-intensive technologies of the energy sector raised more factor income than the capital-intensive energy technologies.*

The combined labor and capital income of the energy sector was the following: traditional ethanol (1687 Cr$), modern ethanol (1639 Cr$), bagasse (1590 Cr$), gasoline (1562 Cr$), coal (1533 Cr$), vegetable charcoal (1492 Cr$), fuelwood (1477 Cr$), electricity (1464 Cr$), other (1368 Cr$), gas (1357 Cr$), kerosene (1315 Cr$), and oil (1072 Cr$). The ethanol industry generated the most factor income within the energy sector. The labor-intensive energy technologies provided more agriculture labor and agriculture capital as well as more non-agriculture labor and non-agriculture capital than the capital-intensive energy technologies.

*B.2.2. The energy sector's labor-intensive technologies raised more labor income to unskilled agriculture labor and unskilled non-agriculture labor than the comparative capital-intensive technologies.*

Unskilled agriculture labor received (12 Cr$) each from the modern and traditional ethanol sectors; (11 Cr$) from the bagasse sector; (7 Cr$) from the vegetable charcoal sector; (6 Cr$) each from the fuelwood, gasoline, and coal sectors; (5 Cr$) from each of the kerosene, oil, gas, and other sectors. Unskilled non-agriculture labor gained (202 Cr$) from the traditional ethanol sector; (180 Cr$) from the kerosene sector; (179 Cr$) from the vegetable charcoal sector; (173 Cr$) each from the gasoline and coal sectors; (168 Cr$) from the fuelwood sector; (159 Cr$) from the electricity sector, (158 Cr$) from the bagasse sector; (155 Cr$) from the gas sector, (151 Cr$) from the other sector; (148 Cr$) from the modern ethanol sector; and (115 Cr$) from the oil sector. Labor-intensive energy technologies provided more income to unskilled agriculture labor and unskilled non-agriculture labor than the capital-intensive energy technologies.

*B3.1 The labor-intensive technologies of the agriculture and manufacturing sectors generated more combined labor and capital income than the comparative capital-intensive technologies.*

The combined factor income produced by the traditional agriculture sector was (1620 Cr$) and (1502 Cr$) by the export agriculture sector. Total capital and labor income provided by the consumer non-durable goods sector was (1543 Cr$) and (1493 Cr$) by the consumer durable goods sector. The service sectors gained the most factor income from the capital-intensive technologies of the public services sector, (1828 Cr$); followed by the financial/services sector, (1603 Cr$); and the private services sector, (1563 Cr$).

*B.3.2. The labor-intensive technologies of the agriculture, manufacturing, and service sectors raised more labor income to unskilled agriculture labor than the comparative capital-intensive technologies. The capital-intensive technologies of the agriculture, manufacturing, and service sectors generated more income to unskilled non-agriculture labor than the comparative labor-intensive technologies.*

Unskilled agriculture labor gained (16 Cr$) from the traditional agriculture sector and (12 Cr$) from the export agriculture sector. The consumer non-durable goods sector raised (10 Cr$) for unskilled agriculture labor; the consumer durable goods sector provided (6 Cr$) to unskilled agriculture labor. Unskilled agriculture labor got (5 Cr$) each from the private and public services sectors, and (3 Cr$) from the financial/commercial services sector.

Unskilled non-agriculture labor received (151 Cr$) from the export agriculture sector and (129 Cr$) from the traditional agriculture sector. Unskilled non-agriculture labor earned (180 Cr$) from the durable consumer goods sector and (167 Cr$) from the consumer non-durable goods sector. Unskilled non-agriculture labor obtained the most from the public service sector, (374 Cr$); followed by the private services sector, (224 Cr$); and (155 Cr$) from the financial/commercial services sector.

This suggests that labor-intensive technologies contributed more to agriculture labor and unskilled agriculture workers and that capital-intensive technologies contributed more to non-agriculture labor and unskilled non-agriculture workers.

C. Household Income Findings

Table 51 gives the household income associated with each production technology. The labor-intensive technologies of the energy, agriculture, and manufacturing sectors provided more household income than the comparative capital-intensive technologies. The capital-intensive technology of the service sector raised more household income than the labor-intensive technologies.

*C.1.1. The labor-intensive technology of the ethanol sector generated more total household income than the capital-intensive technology of the ethanol sector.*

The traditional ethanol sector produced (1775 Cr$) in total household income while the modern ethanol sector raised (1723 Cr$) in total household income.

*C.1.2. The capital-intensive technologies of the ethanol sector generated slightly more income to rural households in poverty than the labor-intensive technology of the ethanol sector. The labor-intensive ethanol technology provided more income to urban households in poverty.*

Table 51. Labor-intensive and capital-intensive technologies and household income.

| | Household Income | Rural HH Income | Urban HH Income | Rural HH in Poverty | Urban HH in Poverty |
|---|---|---|---|---|---|
| LABOR-INT. TECHNOLOGIES | | | | | |
| Traditional Ag | 1734 | 615 | 1119 | 100 | 342 |
| Con Non-Durable Goods | 1723 | 257 | 1466 | 47 | 445 |
| Private Services | 1628 | 141 | 1487 | 25 | 500 |
| | | | | | |
| Energy Sector | | | | | |
| Bagasse | 1666 | 414 | 1253 | 68 | 385 |
| Ethanol-M | 1723 | 453 | 1270 | 74 | 376 |
| Ethanol-T | 1775 | 432 | 1343 | 71 | 449 |
| Electricity | 1644 | 175 | 1469 | 31 | 443 |
| Fuelwood | 1720 | 211 | 1510 | 37 | 468 |
| Vegetable Charcoal | 1737 | 219 | 1518 | 38 | 480 |
| Total Labor-Intensive | 10265 | 1904 | 8362 | 319 | 2601 |
| | | | | | |
| CAPITAL-INT. TECHNOLOGIES | | | | | |
| Export Ag | 1721 | 367 | 1355 | 58 | 416 |
| Con Durable Goods | 1694 | 187 | 1506 | 33 | 466 |
| Financial Services | 1594 | 100 | 1495 | 18 | 382 |
| Public Services | 1912 | 139 | 1773 | 25 | 730 |
| | | | | | |
| Energy Sector | | | | | |
| Coal | 1708 | 178 | 1529 | 31 | 454 |
| Kerosene | 1496 | 163 | 1332 | 29 | 444 |
| Oil | 1240 | 146 | 1094 | 25 | 320 |
| Gasoline | 1732 | 176 | 1556 | 31 | 472 |
| Gas | 1527 | 163 | 1364 | 29 | 418 |
| Other | 1454 | 142 | 1312 | 26 | 394 |
| Total Capital-Intensive | 9156 | 969 | 8188 | 170 | 2501 |

Rural households received (453 Cr$) from the capital-intensive ethanol technology and (432 Cr$) from the labor-intensive ethanol technology. This finding is due to the modern ethanol sector linkage to the traditional agriculture sector.

Specifically, the modern ethanol sector purchased more from the traditional agriculture sector which generated greater agriculture capital that was distributed to the rural households. Rural households in poverty also obtained slightly more income from the modern ethanol sector, (74 Cr$), than the traditional ethanol sector, (71 Cr$).

Urban households received more from the traditional ethanol sector, (1343 Cr$), than from the modern ethanol sector, (1270 Cr$). The traditional ethanol sector pays three times more to unskilled non-agriculture labor and two times more to skilled non-agriculture labor than the modern ethanol sector. This finding is due to the higher labor costs associated with the traditional ethanol sector. The traditional ethanol sector generated (449 Cr$) to urban households in poverty compared to the (376 Cr$) raised by the modern ethanol sector.

*C.2.1. The labor-intensive technologies of the energy sector raised more household income than the capital-intensive technologies.*

The following energy sub-sectors provided the most total household income: traditional ethanol sector, (1775 Cr$); vegetable charcoal sector, (1737 Cr$); gasoline sector, (1732 Cr$); modern ethanol sector, (1723 Cr$); fuelwood sector, (1720 Cr$); coal sector, (1708 Cr$); bagasse sector, (1666 Cr$); electricity sector, (1644 Cr$); gas sector, (1527 Cr$); kerosene sector, (1496 Cr$); other sector, (1454 Cr$); and the oil sector, (1240 Cr$).

*C.2.2. The labor-intensive technologies of the energy sector produced more income to rural and urban households as well as more income to urban and rural households in poverty than the capital-intensive energy technologies.*

The energy sector generated the following income to the rural households: modern ethanol sector, (453 Cr$); traditional ethanol sector, (432 Cr$); bagasse sector, (414 Cr$); vegetable charcoal sector, (219 Cr$); fuelwood sector, (211 Cr$); coal sector, (178 Cr$); gasoline sector, (176 Cr$); electricity sector, (175 Cr$); gas sector, (163 Cr$); kerosene sector, (163 Cr$); oil sector, (146 Cr$); and the other sector, (142 Cr$). Rural households received almost twice as much income from the labor-intensive energy sectors than from capital-intensive energy sectors.

The energy sectors provided the following urban households income: gasoline sector, (1556 Cr$); coal sector, (1529 Cr$); vegetable charcoal sector, (1518 Cr$); fuelwood sector, (1510 Cr$); electricity sector, (1469 Cr$); gas sector, (1364 Cr$); traditional ethanol sector, (1343 Cr$); kerosene sector, (1332 Cr$); other sector, (1312 Cr$); modern ethanol sector, (1270 Cr$); bagasse sector, (1253 Cr$); and the oil sector, (1094 Cr$). Urban households received only slightly more income from the labor-intensive energy technologies than from the capital-intensive energy technologies.

For households in poverty, labor-intensive technologies raised rural incomes by (319 Cr$) compared to (171 Cr$) by the capital-intensive technologies. Urban households in poverty received slightly more income from the labor-intensive technologies (2601 Cr$), compared to the capital-intensive technologies, (2501 Cr$). Labor-intensive energy technologies provided more household income to rural and urban households in poverty than capital-intensive energy technologies.

*C.3.1. The labor-intensive technologies of the agriculture, manufacturing, and energy sectors generated more total household income than the comparative capital-intensive technologies. The capital-intensive of the service sector provided more household income than the labor-intensive technologies.*

Total household income from the traditional agriculture sector was (1734 Cr$), and (1721 Cr$) from the export agriculture sector. The non-durable consumer goods sector raised households income by (1723 Cr$) compared to the (1694 Cr$) by the durable consumer goods sector. The renewable energy technologies generated more total household income (10,265 Cr$) than non-renewable energy technologies (9156 Cr$). The public service sector increased household income by (1912 Cr$), followed by the private services sector, (1628 Cr$), and the financial services sector, (1594 Cr$). The service sectors generated the most household income followed by the agriculture and manufacturing sector.

*C.3.2. The labor-intensive technologies of the agriculture, manufacturing, energy, and service sectors raised more income to rural households and rural households in poverty than the comparative capital-intensive technologies. The capital-intensive* *technologies of the agriculture, manufacturing, and service sectors produced more income to urban households and urban households in poverty.*

The traditional agriculture sector provided (615 Cr$) to rural households and (100 Cr$) to rural households in poverty compared to the export agriculture sector which increased rural household income by (367 Cr$) and (58 Cr$) to rural households poverty. The non-durable goods sector raised household income by (257 Cr$) and (47 Cr$) to the rural households in poverty compared to the durable goods sector which augmented rural household income by (187 Cr$) and (33 Cr$) to the rural households in poverty. Renewable energy technologies provided (1904 Cr$) to rural households and (319 Cr$) to rural households in poverty. Non-renewable energy technologies increased rural household income by (969 Cr$) and (170 Cr$) to rural households in poverty. The private services sector generated the most rural household income, (141 Cr$) and income to rural households in poverty, (25 Cr$); followed by public services sector rural household income, (139 Cr$), income to rural households in poverty, (25 Cr$); and the financial services sector rural household income, (100 Cr$), and income to rural households in poverty, (18 Cr$).

The traditional agriculture sector provided (1119 Cr$) to urban households and (342 Cr$) to urban households in poverty compared to the export agriculture sector which increased urban household income by (1355 Cr$) and (416 Cr$) to urban households poverty. The non-durable goods sector raised household income by (1466 Cr$) and (445 Cr$) to the urban households in poverty compared to the durable goods sector which augmented urban household income by (1506 Cr$) and (466 Cr$) to the urban households in poverty. Renewable energy technologies increased urban households income by (8362 Cr$) and (2601 Cr$) to urban households in poverty. Non-renewable energy technologies generated urban household income of (8188 Cr$) and (2501 Cr$) to urban households in poverty. The private services sector generated the most urban household income, (1487 Cr$) and income to urban households in poverty, (500 Cr$); followed by public services sector urban household income, (1773 Cr$), income to urban households in poverty, (730 Cr$); and the financial services sector urban household income, (1495 Cr$), and income to urban households in poverty, (382 Cr$).

## D. Carbon Dioxide Costs

Table 52. Labor-intensive and capital-intensive technologies and carbon dioxide costs (Cr$).

| Sector | $CO_2$ Costs | | Sector | $CO_2$ Costs |
|---|---|---|---|---|
| Labor-Intensive Tech. | | | Capital-Intensive Tech. | |
| | | | | |
| Trad Agriculture | 2682 | | Export Agriculture | 3655 |
| Consumer Non-Dur | 3306 | | Cons-Dur Goods | 3447 |
| Private Services | 2080 | | Financial Services | 1653 |
| Bagasse | 2303 | | Public Services | 2189 |
| Ethanol-M | 2431 | | Coal | 3279 |
| Ethanol-T | 2442 | | Kerosene | 3030 |
| Electricity | 3251 | | Oil | 2757 |
| Fuelwood | 3863 | | Gasoline | 3242 |
| Vegetable Charcoal | 3884 | | Gas | 3027 |
| | | | Other Energy | 2223 |

Table 52 provides the carbon dioxide costs associated with the comparative production technologies. The labor-intensive technologies of the agriculture and manufacturing sectors had lower carbon dioxide costs than the comparative capital-intensive technologies. The capital-intensive technologies of the energy and service sectors had lower carbon dioxide costs than the comparative labor-intensive technologies.

*D.1. The labor-intensive technology of the ethanol sector had slightly higher $CO_2$ emission costs than the capital-intensive technology of the ethanol sector.*

The traditional ethanol sector had slightly higher $CO_2$ costs (2442 Cr$), than the modern ethanol sector, (2431 Cr$). This is due to the traditional ethanol sector's indirect linkages to the traditional agriculture sector via the households of the urban organized and non-organized workers.

*D.2. The labor-intensive technologies of the energy sector had* greater $CO_2$ *costs than the capital-intensive energy technologies.*

Ranking the energy sub-sectors from the lowest to the highest $CO_2$ costs: other, (2223 Cr$); bagasse, (2303 Cr$); modern ethanol, (2431 Cr$); traditional ethanol, (2442 Cr$); oil, (2757 Cr$); gas, (3027 Cr$); kerosene, (3030 Cr$); gasoline, (3242 Cr$); electricity, (3251 Cr$); coal, (3279 Cr$); fuelwood, (3863

Cr$); and vegetable charcoal, (3884 Cr$). The labor-intensive energy technologies generated (18,174 Cr$) of $CO_2$ costs compared to the capital-intensive energy technologies of (17,558 Cr$).

*D.3. The labor-intensive technologies of the agriculture and manufacturing sectors had lower CO2 costs than the comparative capital-intensive technologies. The most capital-intensive technology of the service sector had lower $CO_2$ costs than the other service sectors.*

The $CO_2$ costs of the traditional agriculture sector, (2682 Cr$), were lower than the export agriculture sector, (3655 Cr$). The $CO_2$ costs of the non-durable consumer goods sector, (3306 Cr$), were lower than the durable consumer goods sector, (3447 Cr$). The financial services sector had the lowest $CO_2$ costs, (1653 Cr$), followed by the private services sector, (2080 Cr$); and the public services sector, (2189 Cr$).

## E. Energy Intensities of Economic Sectors

Table 53 provides the conventional and unconventional energy consumption of the comparative production technologies. The labor-intensive technologies in the agriculture, manufacturing, and service sectors had lower energy requirements than the comparative capital-intensive technologies.

Table 53. Labor-intensive and capital-intensive technologies and energy consumption (Cr$).

| | Oil | Electricity | Fuelwood | Total |
|---|---|---|---|---|
| Export agriculture | 108 | 170 | 97 | 375 |
| Traditional agriculture | 85 | 131 | 76 | 292 |
| Durable consumer goods | 101 | 166 | 90 | 357 |
| Non-durable consumer goods | 98 | 160 | 89 | 347 |
| Financial/commercial services | 51 | 86 | 44 | 181 |
| Public services | 70 | 138 | 59 | 267 |
| Private services | 64 | 111 | 56 | 231 |

The export agriculture, durable consumer goods, and public services sectors consumed more conventional and unconventional energy than the traditional agriculture, non-durable goods, private services and financial/commercial services sectors. The total energy requirement of the export agriculture sector is (375 Cr$) and (292 Cr$) for the traditional agriculture sector. The durable consumer goods sector, (357 Cr$); consumed slightly more compared to the non-durable consumer goods sector, (347 Cr$). The public services sector had the greatest energy requirement, (267 Cr$), followed by the private services sector, (231 Cr$); and the financial/commercial services sector, (181 Cr$). The manufacturing sector consumed the most total energy, followed by the agriculture and service sectors.

## SECTION TWO: RESEARCH CONTRIBUTIONS TO THE LITERATURE

### A. Contributions to Brazil's Alternative Fuel Program Debate

This research makes one novel contribution to the ongoing fuel ethanol dialogue and confirms several findings of previous studies. This is the first empirical study that quantifies the household income effects of Brazil's fuel ethanol program. It was found that the ethanol sectors generate the most household income of the energy sectors. Furthermore, the ethanol sectors provide substantially more rural household income and income to rural households in poverty than the other energy sectors. The ethanol sectors significantly improve household income distribution.

The research findings confirm that the ethanol sectors generate significant employment. The ethanol sectors had the highest employment multipliers of the energy sector. Linkages to the traditional agriculture sector and transportation sector are key sources of indirect employment. Brazil's alternative transportation fuel program contributes to both rural and urban socioeconomic development objectives. As sugarcane is the main feedstock for ethanol production, ethanol has significant linkages to agriculture and industry which in turn has positive employment and income distribution effects.

The research findings confirm that the ethanol sectors produce the most combined labor and capital income. The ethanol sectors raise the most labor income, agriculture labor income and non-agriculture labor income, unskilled agriculture income and unskilled non-agriculture labor income of the energy sectors. Factor income is important because it is the basis of household income.

The ethanol sectors have among the lowest $CO_2$ costs of the energy sector. The source of the ethanol industry's $CO_2$ costs is sugarcane production via the agriculture sector. The use of ethanol is put forth as an effective strategy to mitigate greenhouse gas emissions because it has lower $CO_2$ costs than gasoline. Since the transportation sector accounts for roughly 33% of the $CO_2$ emissions, any strategy which addresses mobile sources must be seriously considered, especially as the number of motor vehicles and total vehicle miles traveled is growing.

B. Contributions to Technology Choice Debate

This research examined several production technologies to capture the direct and indirect employment, factor and household income, and environmental effects due to technology choice. Labor-intensive and capital-intensive technologies were compared in the production of energy, agriculture, manufacturing, and services. Analysis of the dualistic technologies did not find consistent results.

*1. Technology choice and employment.*

It was hypothesized that the relatively labor-intensive technology would generate more employment than the relatively capital-intensive technology. Even though not all labor-intensive technologies generated more employment, the research findings did confirm this hypothesis in all but one economic sector. Contrary to expectations, the employment multiplier of agriculture's capital-intensive technology was greater than that of the agriculture's labor-intensive technology. While the employment multiplier of the modern ethanol sector was slightly larger than the traditional ethanol sector, the difference was not significant. With the exception of the agriculture sector, the labor-intensive technologies of the manufacturing, energy, and service sectors were greater than the comparative capital-intensive technologies. This finding is consistent with the literature that considers both the direct and indirect employment effects.

*2. Technology choice and factor income.*

It was hypothesized that the relatively labor-intensive technologies would provide greater total factor income than the comparative capital-intensive technologies. Even though not all labor-intensive technologies generated total factor income, the research findings did confirm this hypothesis in three out of four economic sectors. The labor intensive technologies of the agriculture, manufacturing, and energy sectors produced more total labor and capital income, more agriculture labor income, and more labor income to unskilled agriculture workers than the comparative capital-intensive technologies. However, the capital-intensive technologies of the agriculture, manufacturing, and energy sectors raised more non-agriculture labor income and more labor income to unskilled non-agriculture workers than the comparative labor-intensive technologies. The capital-intensive technology of the service sector was the only case of a capital-intensive technology providing more factor income than the labor-intensive technology. The findings are consistent with the literature.

*3. Technology choice and household income.*

It was hypothesized that labor-intensive technologies would contribute more to household incomes than capital-intensive technologies. Even though not all labor-intensive technologies provided greater household income, the research findings did confirm this hypothesis in all but one economic sector. The labor-intensive technologies of the energy, agriculture, and manufacturing sectors provided more household income than the comparative capital-intensive technologies. The capital-intensive technology of the service sector raised more household income than the labor-intensive technologies. The labor-intensive technologies of the agriculture, manufacturing, energy, and service sectors raised more income to rural households and rural households in poverty. The capital-intensive technology of the agriculture, manufacturing, and service sectors increased income to urban households and urban households in poverty. The labor-intensive technologies of the energy sector generated more income to urban households and urban households in poverty than the capital-intensive technologies. The service sectors generated the most household income followed by the agriculture and manufacturing sector. The findings are consistent with the literature that considers household income.

*4. Technology choice and the environment.*

It was hypothesized that the labor-intensive technologies would have lower $CO_2$ costs than the relatively capital-intensive technologies. The research findings did confirm this hypothesis in two out of four economic sectors. The labor-intensive technologies of the agriculture and manufacturing sectors had lower $CO_2$ costs than the comparative capital-intensive technologies, whereas, the capital-intensive technologies of the energy and service sectors had lower $CO_2$ costs than the comparative labor-intensive technology. The labor-intensive technologies of the energy sector, namely the fuelwood and vegetable charcoal sectors had the highest $CO_2$ costs of the energy sector. The labor-intensive service technology, private services sector, had lesser $CO_2$ costs than the capital-intensive technology of the public services sector and higher carbon cost than the most capital-intensive service technology, financial services sector. The service sectors have the lowest $CO_2$ costs compared to the agriculture, manufacturing, and energy sectors.

*5. Technology choice and energy intensity.*

The energy intensity of the agriculture, manufacturing, and service sectors was examined because of the direct link between energy consumption and $CO_2$ emissions. The oil and electricity energy sub-sectors were the conventional energy sources; the fuelwood sector was the unconventional energy source. It was hypothesized that the labor-intensive technologies would have lower energy intensities than the comparative capital-intensive technologies. The labor-intensive technologies of the agriculture, manufacturing, and service sectors had lower energy requirements than the comparative capital-intensive technologies.

C. Contributions to SAM Methodology

This research makes two important contributions to the SAM methodology. First, it is one of the first SAM modeling analyses that quantifies the impact of carbon dioxide emissions. Second, it is the first study that quantifies impact of alternative fuels on regional and human development in a newly industrialized economy. The addition of an environmental sector and an alternative fuel sector in the SAM-based modeling enables the planner to see the consequences of the carbon dioxide and alternative energy effects in different socioeconomic sectors. In addition, it improves SAM-based modeling and will enhance the development planning process particularly by countries that have the capacity to develop an ethanol transportation fuel substitute and that have significant energy related $CO_2$ emissions.

The SAM modeling methodology of this research is one of the first to conceptualize the effects of carbon dioxide costs on human development. The research made a first measurement of the direct and indirect impacts of Brazil's energy carbon dioxide costs on Brazil's socioeconomic sectors. It showed the linkages of energy sector $CO_2$ emission costs to other socioeconomic sectors.

The incorporation of an environmental sector and regional economic sector into SAM-based modeling furthers the understanding of social development because it identifies the magnitude of the direct and indirect effects as well as the inter-regional and intra-regional linkages among production, employment, and household income distribution and consumption. Quantifying the energy related $CO_2$ costs and including a $CO_2$ sector are a significant contribution to economy-wide models which typically do not provide this kind of detail.

The research contributes to the regional development dialogue because it demonstrated the ability of SAM-based modeling to enrich the understanding of social development at the regional and national level. Incorporating more regional sectors such as the traditional and modern ethanol sector strengthens SAM-based modeling because it captures not only the direct and indirect effects, but also the inter-regional and intra-regional effects of a change in an economic sector on employment and on households. Clarification of the inter-regional and intra-regional effects of investment in certain sectors promotes a greater understanding of the regional development process. Given sufficient data, modeling based on SAMs can identify the regions and the economic sectors that contribute most toward development objectives. For example, if rural poverty alleviation is an important goal, then regional SAM-based modeling can show which region and which economic sectors have greater linkages with unskilled agriculture labor and rural households in poverty.

## SECTION THREE: POLICY IMPLICATIONS

The findings of this research have several policy implications.

1. The research findings suggest that the adoption of an alternative transportation fuel policy based on renewable energy may help realize multiple macroeconomic objectives. First, the development of a domestic gasoline substitute has a positive effect on the country's trade balance. Reduced petroleum imports have improved Brazil's balance of payments and have resulted in significant foreign exchange savings. As the global demand for energy services is growing at 2% per annum, the demand for motor vehicle transportation is increasing. Transportation fuel substitutes will insulate a country's vulnerability to disruptions in energy supply or to risks of foreign indebtedness.

2. Domestically, the ethanol industry has contributed to the diversification of Brazil's energy supply and led to the transformation of the sugar industry into sugar, ethanol, and bagasse industries. The investment requirements of the ethanol sector are among the lowest of economic sectors. Investment costs are \$6000-\$7000 per person-year in the N/E region and \$23,000-\$28,000 per person-year in the C/S region compared to \$42,000 per person-year in the industrial sector or \$200,000 per person-year in the petrochemical sector.

Ethanol's agroindustrial linkages are of particular importance to Brazil. Between 1980 and 1988, the agriculture sector's relative economic strength had a stabilizing effect on the economy. The ethanol industry will continue to contribute to the development and strengthening of the agriculture sector.

3. The environmental benefits associated with a renewable transportation fuel are significant. The transportation sector accounts for 33% of Brazil's energy-related carbon dioxide emissions. The production and use of ethanol results in significantly lower $CO_2$ costs compared to fossil fuel-based gasoline. The use of ethanol has improved air quality and has eliminated the need for lead in gasoline. Stillage, a by-product of the ethanol's production cycle is now treated and used as a fertilizer for the agriculture sector.

4. Countries with adequate land mass may find a biomass-based transportation fuel policy a means to achieve positive energy, economic, and environmental goals. However, two caveats are needed. One concern is oil prices. Low oil prices make the ethanol program more expensive. The government will have to consider the opportunity costs of subsidies and incentives to the industry to determine if it is economically efficient. Another concern is potential land use conflicts. As long as there is an sufficient agricultural land and low population densities, then the substitution of sugarcane should not be in conflict with the

production of food staples. However, diversifying the feedstock of ethanol to include cellulosic biomass, particularly fuelwood, may aggravate the fuelwood crisis in developing countries.

5. The research findings suggest that labor-intensive technologies may have many positive contributions to sustainable development. Brazil's past industrialization policies have favored the development of capital-intensive industry. The result has been underemployment and increased income inequality. The labor-intensive technologies of Brazil's agriculture, manufacturing, energy, and service industries have many direct and indirect linkages to other socioeconomic sectors. The labor-intensive technologies generate significant employment, factor and household income, and environmental benefits to Brazil's economy. In addition, these technologies make a particular contribution to rural development, which is important as rural migration to urban centers puts increasing strains on urban systems.

6. This research suggests that there are major differences in employment, income generation and distribution, and environmental effects due to technology choice. These differences are captured through the methodology of social accounting matrix-based modeling. The research findings confirm the key finding of the appropriate technology literature. Government policies are necessary for the

adoption and implementation of appropriate technologies. The state's use of investment-promoting taxes, exchange and credit controls, import quotas, farm price supports, and consumption incentives were important to the development of Brazil's alternative fuel program.

Concluding Comment.

The overall objective of this research was to determine the effects of technology choice on development, particularly poverty alleviation in Brazil. It was found that labor-intensive technologies, especially in the agriculture and renewable energy sectors, are important because of their intersectoral linkages within the economy. They make a particular contribution to poverty alleviation. These findings suggest that policies to support the adoption of labor-intensive technologies will positively contribute to socioeconomic development.

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Appendix 1 'Social Accounting Matrix, Brazil, 1985, Transaction Matrix
(Millions of Cruzeiros)



| | | A-unskill | A-skilled | A-mgrs | A-capital | U-unskill | U-skill | U-mgrs | U-capital | R-capitalist | R-sm prod | R-workers | R-mgrs | U-capital | U-mgrs | U-sm prod |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | HH1 | HH2 | HH3 | HH4 | HH5 | HH6 | HH7 |
| Unskilled Ag Labor | F1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Ag Labor | F2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof Ag Labor | F3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ag Capital | F4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unskilled Non Ag Labor | F5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Non-Ag Labor | F6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Non-Ag Labor | F7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-Ag Capital | F8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Capitalists | HH1 | 0 | 0 | 0 | 66341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Sm Producers | HH2 | 1449 | 8838 | 0 | 33113 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Workers/Tenant Farmers | HH3 | 3780 | 8923 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Mgrs /Prof | HH4 | 0 | 1258 | 1039 | 9212 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Capitalists | HH5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 302122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Mgrs /Prof | HH6 | 0 | 0 | 0 | 0 | 0 | 0 | 81491 | 57592 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Sm Producers | HH7 | 0 | 0 | 0 | 0 | 16302 | 36737 | 0 | 236097 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Organized Workers | HH8 | 0 | 0 | 0 | 0 | 73922 | 1E+05 | 0 | 16893 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Non-Organized Workers | HH9 | 448 | 0 | 0 | 0 | 101072 | 66739 | 0 | 11331 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Export Agriculture | A101 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 37 | 69 | 6 | 17 | 45 | 274 |
| Traditional Agriculture | A102 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 224 | 665 | 484 | 140 | 1020 | 1054 | 5016 |
| Livestock | A103 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 63 | 265 | 127 | 50 | 288 | 378 | 1997 |
| Mineral Extraction | A104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 5 | 0 | 0 | 1 | 79 |
| Non-Mineral Extraction | A105 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Durable Consumer Goods | A106 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3054 | 1847 | 249 | 969 | 13910 | 7310 | 13929 |
| Non-Durable Consumer Goods | A107 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3103 | 7811 | 4811 | 1764 | 14128 | 13314 | 58901 |
| Intermediate Goods | A108 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 161 | 278 | 100 | 83 | 730 | 626 | 2095 |
| Capital Goods | A109 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 19 | 27 | 6 | 89 | 43 | 145 |
| Energy | A110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1027 | 1012 | 208 | 459 | 4675 | 3467 | 7636 |
| Civil Construction | A111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Financial/Commercial Services | A112 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4686 | 6990 | 3051 | 2068 | 21338 | 15600 | 52711 |
| Commerce | A113 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3633 | 5420 | 2365 | 1603 | 16543 | 12095 | 40865 |
| Transportation/Communication | A114 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4110 | 6885 | 3087 | 1907 | 18713 | 14391 | 51918 |
| Public Services | A115 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 357 | 435 | 76 | 143 | 1624 | 1077 | 3277 |
| Private Services | A116 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5141 | 5049 | 945 | 1915 | 23406 | 14450 | 38072 |
| Government | G | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8904 | 2602 | 633 | 2760 | 40546 | 20821 | 19624 |
| Indirect Taxes | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subsidies | S | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Domestic Capital Formation | K | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31546 | 6459 | 1461 | 8723 | 143651 | 65808 | 48710 |
| Rest of the World - Current | RC | 0 | 0 | 0 | 12347 | 0 | 0 | 317 | 110145 | 318 | 0 | 0 | 110 | 1447 | 832 | 0 |
| Rest of the World - Capital | RK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 5677 | 19019 | 1039 | 121013 | 191296 | 2E+05 | 81808 | 734180 | 66349 | 45784 | 17698 | 22706 | 302125 | 171312 | 345249 |

Appendix 1. Social Accounting Matrix, Brazil, 1985, Transaction Matrix
(Millions of Cruzeiros)

| | U-wrkrs HH8 | U-unorg wrk HH9 | Ag-Export A101 | Ag-Trad A102 | Livestock A103 | Minerals A104 | Non-min A105 | Cons-Dur A106 | Con-ND A107 | Intermed A108 | Capital A109 | Energy A110 | Construct A111 | Financial A112 | Commerce A113 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unskilled Ag Labor | 0 | 0 | 759 | 1656 | 3262 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Ag Labor | 0 | 0 | 1703 | 7693 | 9624 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Ag Labor | 0 | 0 | 24 | 889 | 126 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ag Capital | 0 | 0 | 23767 | 70292 | 26950 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unskilled Non Ag Labor | 0 | 0 | 0 | 0 | 0 | 638 | 2744 | 5102 | 10817 | 23843 | 11544 | 2927 | 5761 | 17560 | 8581 |
| Skilled Non-Ag Labor | 0 | 0 | 0 | 0 | 0 | 2189 | 8783 | 6239 | 17045 | 14782 | 10390 | 2975 | 14820 | 21623 | 13861 |
| Mgrs/Prof. Non-Ag Labor | 0 | 0 | 0 | 0 | 0 | 312 | 1172 | 2551 | 3884 | 13282 | 6102 | 1069 | 3382 | 9418 | 3890 |
| Non-Ag Capital | 0 | 0 | 0 | 0 | 0 | 16826 | 19190 | 19930 | 70286 | 102276 | 23908 | 24001 | 43107 | 199946 | 73558 |
| Rural Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Workers/Tenant Farmers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Non-Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Export Agriculture | 388 | 745 | 222 | 475 | 196 | 0 | 3 | 2668 | 26571 | 1066 | 5 | 0 | 0 | 0 | 0 |
| Traditional Agriculture | 4084 | 5203 | 278 | 8003 | 4004 | 18 | 0 | 41 | 40581 | 9933 | 5 | 12928 | 0 | 0 | 0 |
| Livestock | 1643 | 1357 | 563 | 2113 | 966 | 0 | 0 | 0 | 36913 | 269 | 0 | 0 | 0 | 0 | 0 |
| Mineral Extraction | 14 | 58 | 0 | 422 | 272 | 2140 | 49 | 126 | 2044 | 12870 | 334 | 51 | 2265 | 0 | 0 |
| Non-Mineral Extraction | 0 | 0 | 0 | 0 | 0 | 8 | 48 | 14 | 12 | 2211 | 13 | 44495 | 0 | 0 | 0 |
| Durable Consumer Goods | 6052 | 2674 | 0 | 0 | 108 | 82 | 38 | 16285 | 766 | 1295 | 1715 | 54 | 7098 | 132 | 200 |
| Non-Durable Consumer Goods | 44754 | 51697 | 435 | 453 | 112 | 96 | 113 | 456 | 53642 | 6678 | 557 | 3767 | 351 | 1351 | 71 |
| Intermediate Goods | 1232 | 1073 | 3875 | 9891 | 8386 | 2077 | 2412 | 19183 | 50163 | 247570 | 41828 | 2604 | 69009 | 8452 | 5708 |
| Capital Goods | 139 | 282 | 43 | 246 | 57 | 1216 | 2825 | 17341 | 2863 | 10773 | 28205 | 1614 | 9744 | 430 | 537 |
| Energy | 2740 | 2237 | 863 | 2526 | 1311 | 1542 | 458 | 1101 | 4281 | 16798 | 1670 | 9950 | 3711 | 396 | 23937 |
| Civil Construction | 0 | 0 | 0 | 0 | 5 | 89 | 289 | 235 | 645 | 963 | 363 | 243 | 10038 | 14743 | 498 |
| Financial/Commercial Services | 33286 | 32784 | 451 | 1356 | 150 | 1974 | 4278 | 5412 | 12862 | 19631 | 5235 | 4794 | 5076 | 262177 | 11238 |
| Commerce | 25805 | 25417 | 54 | 135 | 71 | 493 | 380 | 2546 | 6154 | 7652 | 2732 | 1467 | 371 | 0 | 2254 |
| Transportation/Communication | 33527 | 33173 | 222 | 562 | 292 | 436 | 387 | 1395 | 3408 | 4110 | 1137 | 3903 | 457 | 3429 | 7153 |
| Public Services | 1636 | 814 | 14 | 38 | 32 | 110 | 120 | 170 | 579 | 1751 | 260 | 193 | 49 | 267 | 351 |
| Private Services | 15664 | 10149 | 249 | 630 | 327 | 909 | 1189 | 2299 | 5434 | 6588 | 2333 | 963 | 3138 | 8748 | 3611 |
| Government | 11891 | 6806 | 1001 | 2962 | 1135 | 1235 | 1409 | 1464 | 5161 | 7511 | 1756 | 1763 | 3166 | 14684 | 5402 |
| Indirect Taxes | 0 | 0 | 347 | 1015 | 565 | 1280 | 1098 | 3885 | 0 | 22282 | 6740 | 0 | 23116 | 23781 | 28821 |
| Subsidies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Domestic Capital Formation | 28452 | 15697 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rest of the World - Current | 0 | 0 | 9 | 28 | 16 | 48 | 203 | 1131 | 3991 | 8298 | 1966 | 29964 | 632 | 2127 | 326 |
| Rest of the World - Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 211307 | 190166 | 34879 | 111385 | 57967 | 33718 | 47188 | 109574 | 358102 | 542432 | 148798 | 149725 | 205291 | 589264 | 189997 |

Appendix 1. Social Accounting Matrix, Brazil, 1985, Transaction Matrix



| | Transport A114 | Public A115 | Private A116 | Gov't G | Ind Tax T | Subsidies S | DCF K | ROW-C RC | ROW-K RK | |
|---|---|---|---|---|---|---|---|---|---|---|
| Unskilled Ag Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5677 |
| Skilled Ag Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19020 |
| Mgrs/Prof. Ag Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1039 |
| Ag Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1E+05 |
| Unskilled Non Ag Labor | 14380 | 69732 | 17662 | 0 | 0 | 0 | 0 | 0 | 0 | 2E+05 |
| Skilled Non-Ag Labor | 15321 | 57650 | 18295 | 0 | 0 | 0 | 0 | 0 | 0 | 2E+05 |
| Mgrs/Prof. Non-Ag Labor | 5464 | 25333 | 5909 | 0 | 0 | 0 | 0 | 38 | 0 | 81806 |
| Non-Ag Capital | 64523 | 17902 | 42187 | 0 | 0 | 0 | 0 | 16519 | 0 | 7E+05 |
| Rural Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 66353 |
| Rural Sm. Producers | 0 | 0 | 0 | 2388 | 0 | 0 | 0 | 0 | 0 | 45788 |
| Rural Workers/Tenant Farmers | 0 | 0 | 0 | 4995 | 0 | 0 | 0 | 0 | 0 | 17698 |
| Rural Mgrs./Prof. | 0 | 0 | 0 | 11100 | 0 | 0 | 0 | 98 | 0 | 22707 |
| Urban Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 0 | 3E+05 |
| Urban Mgrs./Prof. | 0 | 0 | 0 | 32070 | 0 | 0 | 0 | 175 | 0 | 2E+05 |
| Urban Sm Producers | 0 | 0 | 0 | 56142 | 0 | 0 | 0 | 0 | 0 | 3E+05 |
| Urban Organized Workers | 0 | 0 | 0 | 20010 | 0 | 0 | 0 | 0 | 0 | 2E+05 |
| Urban Non-Organized Workers | 0 | 0 | 0 | 10595 | 0 | 0 | 0 | 0 | 0 | 2E+05 |
| Export Agriculture | 0 | 0 | 139 | 0 | 0 | 146 | 98 | 1704 | 0 | 34877 |
| Traditional Agriculture | 49 | 3131 | 2148 | 0 | 0 | 683 | 8510 | 3180 | 0 | 1E+05 |
| Livestock | 0 | 34 | 261 | 0 | 0 | 297 | 10243 | 138 | 0 | 57965 |
| Mineral Extraction | 0 | 0 | 0 | 0 | 0 | 0 | 669 | 12308 | 0 | 33717 |
| Non-Mineral Extraction | 0 | 354 | 0 | 0 | 0 | 0 | 0 | 32 | 0 | 47187 |
| Durable Consumer Goods | 1605 | 491 | 2042 | 0 | 0 | 952 | 14144 | 12575 | 0 | 1E+05 |
| Non-Durable Consumer Goods | 829 | 5544 | 28867 | 0 | 0 | 5992 | 969 | 47524 | 0 | 4E+05 |
| Intermediate Goods | 9772 | 7594 | 15637 | 0 | 0 | 602 | 2642 | 28631 | 0 | 5E+05 |
| Capital Goods | 13334 | 5550 | 12377 | 0 | 0 | 1216 | 24032 | 15623 | 0 | 1E+05 |
| Energy | 35217 | 8124 | 1116 | 0 | 0 | 4933 | 2825 | 5498 | 0 | 1E+05 |
| Civil Construction | 2008 | 2154 | 900 | 0 | 0 | 17 | 2E+05 | 1956 | 0 | 2E+05 |
| Financial/Commercial Services | 8580 | 48558 | 8223 | 0 | 0 | 1173 | 11601 | 3963 | 0 | 6E+05 |
| Commerce | 0 | 978 | 0 | 0 | 0 | 6625 | 8094 | 16242 | 0 | 2E+05 |
| Transportation/Communication | 13079 | 4892 | 820 | 0 | 0 | 2811 | 451 | 16563 | 0 | 2E+05 |
| Public Services | 219 | 6658 | 464 | 3E+05 | 0 | 13 | 0 | 0 | 0 | 3E+05 |
| Private Services | 12842 | 16177 | 6066 | 0 | 0 | 315 | 0 | 32 | 0 | 2E+05 |
| Government | 4738 | 1314 | 3098 | 0 | 146168 | 0 | 93637 | 0 | 0 | 4E+05 |
| Indirect Taxes | 25832 | 13159 | 20015 | 0 | 0 | 0 | 0 | 0 | 0 | 2E+05 |
| Subsidies | 0 | 0 | 0 | 0 | 25774 | 0 | 0 | 0 | 0 | 25774 |
| Domestic Capital Formation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2267 | 4E+05 |
| Rest of the World - Current | 5434 | 280 | 419 | 0 | 0 | 0 | 4077 | 0 | 0 | 2E+05 |
| Rest of the World - Capital | 0 | 0 | 0 | 0 | 0 | 0 | 651 | 1616 | 0 | 2267 |
| Total | 233226 | 3E+05 | 186645 | 4E+05 | 171942 | 25775 | 4E+05 | 184456 | 2267 | |

Appendix 2. Social Accounting Matrix SAM-TECH, Brazil, 1985, Transaction Matrix
(Millions of Cruzeiros)

| | | A-unskill | A-skilled | A-mgrs | A-capital | U-unskill | U-skill | U-mgrs | U-capital | R-capitalist | R-sm prod | R-workers | R-mgrs | U-capital | U-mgrs | U-sm prod | U-org lab | U-unorg la | Ag-Export |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | HH11 | HH12 | HH13 | HH14 | HH15 | HH16 | HH17 | HH18 | HH19 | A101 |
| Unskilled Ag. Labor | F1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 759 |
| Skilled Ag. Labor | F2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1703 |
| Mgrs/Prof. Ag Labor | F3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 |
| Ag Capital | F4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23767 |
| Unskilled Non Ag. Labor | F5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Non-Ag. Labor | F6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Non-Ag Labor | F7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-Ag. Capital | F8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Capitalists | HH11 | 0 | 0 | 0 | 66341 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Sm. Producers | HH12 | 1449 | 8838 | 0 | 33110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Workers/Tenant Farmers | HH13 | 3780 | 8923 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Mgrs./Prof. | HH14 | 0 | 1239 | 1039 | 9211 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Capitalists | HH15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 302122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Mgrs./Prof. | HH16 | 0 | 0 | 0 | 0 | 0 | 0 | 81489 | 57592 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Sm. Producers | HH17 | 0 | 0 | 0 | 0 | 16302 | 36737 | 0 | 236097 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Organized Workers | HH18 | 0 | 0 | 0 | 0 | 73922 | 100497 | 0 | 16893 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Non-Organized Workers | HH19 | 448 | 0 | 0 | 0 | 101067 | 66739 | 0 | 11331 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Export Agriculture | A101 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 37 | 69 | 6 | 17 | 45 | 274 | 388 | 745 | 222 |
| Traditional Agriculture | A102 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 224 | 665 | 484 | 140 | 1020 | 1054 | 5016 | 4084 | 5203 | 278 |
| Livestock | A103 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 63 | 265 | 127 | 50 | 288 | 378 | 1997 | 1643 | 1357 | 563 |
| Mineral Extraction | A104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 5 | 0 | 0 | 1 | 79 | 14 | 58 | 0 |
| Non-Mineral Extraction | A105 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Durable Consumer Goods | A106 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3054 | 1847 | 249 | 969 | 13910 | 7310 | 13929 | 6032 | 2674 | 0 |
| Non-Durable Consumer Goods | A107 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3103 | 7811 | 4811 | 1764 | 14128 | 13314 | 58901 | 44754 | 51697 | 435 |
| Intermediate Goods | A108 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 161 | 278 | 100 | 83 | 730 | 626 | 2095 | 1232 | 1073 | 3875 |
| Capital Goods | A109 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 19 | 27 | 6 | 89 | 43 | 145 | 139 | 282 | 43 |
| Coal (Coal Steam and Coke) | E110-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bagasse | E110-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kerosene | E110-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 30 | 0 | 0 | 0 | 19 | 18 | 35 | 0 |
| Oil (diesel, fuel, naphtha) | E110-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 365 |
| Gasoline | E110-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 117 | 0 | 60 | 1291 | 601 | 1082 | 106 | 0 | 0 |
| Ethanol-M | E110-6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 34 | 1016 | 370 | 277 | 0 | 0 | 0 |
| Ethanol-T | E110-7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 0 | 32 | 976 | 355 | 266 | 0 | 0 | 0 |
| Gas (LPG,city gas, natural gas) | E110-8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 122 | 36 | 48 | 314 | 435 | 1395 | 643 | 464 | 0 |
| Electricity | E110-9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 858 | 0 | 0 | 0 | 1055 | 1620 | 3621 | 1234 | 757 | 270 |
| Fuelwood | E110-10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 725 | 92 | 285 | 47 | 86 | 951 | 666 | 760 | 365 |
| Veg. Charcoal | E110-11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 47 | 0 | 0 | 14 | 54 | 88 | 235 | 0 |
| Other | E110-12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1027 | 1012 | 205 | 459 | 4699 | 3481 | 7665 | 2735 | 2251 | 1000 |
| Civil Construction | A111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Financial/Commercial Services | A112 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4686 | 6990 | 3051 | 2068 | 21338 | 15600 | 52711 | 33286 | 32784 | 451 |
| Commerce | A113 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3633 | 5420 | 2365 | 1603 | 16543 | 12095 | 40865 | 25805 | 25417 | 54 |
| Transportation/Communication | A114 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4110 | 6885 | 3087 | 1907 | 18713 | 14391 | 51918 | 33527 | 33173 | 222 |
| Public Services | A115 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 357 | 439 | 76 | 144 | 1624 | 1077 | 3277 | 1636 | 814 | 14 |
| Private Services | A116 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5141 | 5049 | 945 | 1915 | 23406 | 14430 | 38072 | 15664 | 10149 | 249 |
| Carbon Dioxide Pollution | CO2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11655 | 7625 | 2232 | 2022 | 53077 | 24434 | 50795 | 33611 | 31550 | 105705 |
| Government | G | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8908 | 2602 | 633 | 2760 | 40546 | 20821 | 19624 | 11891 | 6806 | 1001 |
| Indirect Taxes | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 347 |
| Subsidies | S | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Capital | DKF | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31546 | 6456 | 1464 | 8723 | 143651 | 65808 | 48710 | 28452 | 15697 | 0 |
| ROW-Current | ROW-C | 0 | 0 | 0 | 12347 | 0 | 0 | 317 | 110143 | 318 | 0 | 0 | 110 | 1449 | 832 | 0 | 0 | 0 | 9 |
| ROW-Capital | ROW-K | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Column Sum | | 5677 | 19020 | 1039 | 121009 | 191291 | 203973 | 81806 | 734178 | 79035 | 54422 | 20135 | 25188 | 359927 | 199241 | 403738 | 247688 | 223981 | 141721 |

Social Accounting Matrix SAM-TECH, Brazil, 1985, Transaction Matrix
(Millions of Cruzeiros)



| | | Ag-Trad A102 | Livestock A103 | Minerals A104 | Non-min A105 | Cons-Dur A106 | Con-ND A107 | Intermed. A108 | Capital A109 |
|---|---|---|---|---|---|---|---|---|---|
| Unskilled Ag. Labor | | 1636 | 3262 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Ag. Labor | | 7693 | 9624 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Ag Labor | | 889 | 126 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ag Capital | | 70292 | 26950 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unskilled Non Ag. Labor | | 0 | 0 | 638 | 2744 | 5102 | 10817 | 23843 | 11544 |
| Skilled Non-Ag. Labor | | 0 | 0 | 2189 | 8783 | 6239 | 17045 | 14782 | 10390 |
| Mgrs/Prof. Non-Ag Labor | | 0 | 0 | 312 | 1172 | 2551 | 3884 | 13282 | 6102 |
| Non-Ag. Capital | | 0 | 0 | 16826 | 19190 | 19930 | 70286 | 102276 | 23908 |
| Rural Capitalists | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Sm. Producers | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Workers/Tenant Farmers | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Mgrs./Prof. | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Capitalists | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Mgrs./Prof. | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Sm. Producers | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Organized Workers | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Non-Organized Workers | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Export Agriculture | | 475 | 196 | 0 | 3 | 2668 | 26571 | 1066 | 5 |
| Traditional Agriculture | | 8003 | 4004 | 18 | 0 | 41 | 40581 | 9933 | 5 |
| Livestock | | 2113 | 966 | 0 | 0 | 0 | 36913 | 269 | 0 |
| Mineral Extraction | | 422 | 272 | 2140 | 49 | 126 | 2044 | 12870 | 334 |
| Non-Mineral Extraction | | 0 | 0 | 8 | 48 | 14 | 12 | 2211 | 13 |
| Durable Consumer Goods | | 0 | 108 | 82 | 38 | 16285 | 766 | 1295 | 1715 |
| Non-Durable Consumer Goods | | 453 | 112 | 96 | 113 | 456 | 53642 | 6678 | 557 |
| Intermediate Goods | | 9891 | 8386 | 2077 | 2412 | 19183 | 50163 | 247570 | 41828 |
| Capital Goods | | 246 | 57 | 1216 | 2825 | 17341 | 2863 | 10773 | 28205 |
| Coal (Coal Steam and Coke) | | 0 | 0 | 0 | 0 | 0 | 43 | 5625 | 510 |
| Bagasse | | 0 | 0 | 0 | 0 | 0 | 0 | 5191 | 0 |
| Kerosene | | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 12 |
| Oil (diesel, fuel, naphtha) | | 960 | 67 | 607 | 257 | 0 | 520 | 1061 | 275 |
| Gasoline | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ethanol-M | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ethanol-T | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gas (LPG, city gas, natural gas) | | 0 | 0 | 0 | 93 | 0 | 37 | 69 | 28 |
| Electricity | | 600 | 445 | 846 | 103 | 1101 | 2571 | 3326 | 842 |
| Fuelwood | | 874 | 797 | 55 | 0 | 0 | 1084 | 1525 | 0 |
| Veg. Charcoal | | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 |
| Other | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 2434 | 1309 | 1541 | 453 | 1101 | 4269 | 16797 | 1667 |
| Civil Construction | | 0 | 5 | 89 | 289 | 235 | 645 | 963 | 363 |
| Financial/Commercial Services | | 1356 | 150 | 1974 | 4278 | 5412 | 12862 | 19631 | 5235 |
| Commerce | | 135 | 71 | 493 | 380 | 2546 | 6154 | 7652 | 2732 |
| Transportation/Communication | | 562 | 292 | 436 | 387 | 1395 | 3408 | 4110 | 1137 |
| Public Services | | 38 | 32 | 110 | 120 | 172 | 579 | 1751 | 260 |
| Private Services | | 630 | 327 | 909 | 1189 | 2299 | 5434 | 6588 | 2333 |
| Carbon Dioxide Pollution | | 57045 | 0 | 0 | 0 | 142210 | 318595 | 324107 | 39687 |
| Government | | 2962 | 1135 | 1235 | 1409 | 1464 | 5161 | 7511 | 1736 |
| Indirect Taxes | | 1015 | 565 | 1280 | 1098 | 3885 | 0 | 22282 | 6740 |
| Subsidies | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Capital | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ROW-Current | | 28 | 16 | 48 | 203 | 1131 | 3991 | 8298 | 1966 |
| ROW-Capital | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 170772 | 59274 | 35258 | 47636 | 252887 | 680954 | 883335 | 190149 |

| | Coal E110-1 | Bagasse E110-2 | Kerosene E110-3 | Oil E110-4 | Gasoline E110-5 | Ethanol-M E110-6 | Ethanol-T E110-7 | Gas E110-8 | Electricity E110-9 | Fuelwood E110-10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Unskilled Ag. Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Ag. Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Ag Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ag Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unskilled Non Ag. Labor | 292 | 293 | 293 | 146 | 293 | 100 | 339 | 293 | 293 | 146 |
| Skilled Non-Ag. Labor | 200 | 250 | 290 | 340 | 395 | 120 | 240 | 330 | 390 | 120 |
| Mgrs/Prof. Non-Ag Labor | 114 | 53 | 53 | 207 | 107 | 82 | 25 | 107 | 215 | 53 |
| Non-Ag. Capital | 2206 | 1150 | 413 | 5981 | 2400 | 666 | 589 | 1720 | 8346 | 240 |
| Rural Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Workers/Tenant Farmers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Non-Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Export Agriculture | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Traditional Agriculture | 0 | 5136 | 0 | 0 | 0 | 3193 | 2904 | 0 | 0 | 855 |
| Livestock | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mineral Extraction | 51 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-Mineral Extraction | 1446 | 249 | 0 | 13 | 3938 | 0 | 0 | 2275 | 25810 | 7473 |
| Durable Consumer Goods | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-Durable Consumer Goods | 339 | 0 | 65 | 411 | 208 | 80 | 76 | 133 | 1302 | 311 |
| Intermediate Goods | 234 | 0 | 45 | 306 | 143 | 55 | 53 | 92 | 901 | 214 |
| Capital Goods | 197 | 0 | 0 | 175 | 89 | 54 | 51 | 52 | 646 | 150 |
| Coal (Coal Steam and Coke) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bagasse | 0 | 6396 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kerosene | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oil (diesel, fuel, naphtha) | 0 | 0 | 0 | 1917 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gasoline | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ethanol-M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ethanol-T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gas (LPG, city gas, natural gas) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Electricity | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1637 | 0 |
| Fuelwood | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Veg. Charcoal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 6396 | 0 | 1917 | 0 | 0 | 0 | 0 | 1637 | 0 |
| Civil Construction | 43 | 0 | 0 | 0 | 0 | 46 | 44 | 0 | 110 | 0 |
| Financial/Commercial Services | 233 | 283 | 133 | 434 | 264 | 101 | 97 | 170 | 2076 | 396 |
| Commerce | 132 | 142 | 25 | 157 | 81 | 31 | 30 | 52 | 511 | 121 |
| Transportation/Communication | 351 | 312 | 170 | 622 | 215 | 83 | 79 | 228 | 1061 | 360 |
| Public Services | 17 | 15 | 3 | 44 | 11 | 4 | 4 | 10 | 56 | 16 |
| Private Services | 87 | 77 | 17 | 131 | 53 | 20 | 20 | 34 | 332 | 80 |
| Carbon Dioxide Pollution | 8570 | 0 | 3395 | 41912 | 11477 | 0 | 0 | 10746 | 75802 | 51117 |
| Government | 170 | 92 | 32 | 180 | 103 | 40 | 38 | 73 | 652 | 95 |
| Indirect Taxes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subsidies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ROW-Current | 139 | 400 | 959 | 19772 | 144 | 57 | 56 | 2337 | 5673 | 230 |
| ROW-Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 14875 | 21244 | 5893 | 74665 | 19921 | 4732 | 4645 | 18652 | 127450 | 61977 |

Social Accounting Matrix SAM-TECH, Brazil, 1985, Transaction Matrix
(Millions of Cruzeiros)



| | Veg. Char E110-11 | Other E110-12 | | Construct A111 | Financial A112 | Commerce A113 | Transport A114 | Public A115 | Private A116 | CO2 CO2 | Gov't G | Ind Taxes T | Subsidies S | Capital DKF | ROW-Cur ROW-C | ROW-Cap ROW-K | Row Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unskilled Ag. Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5677 |
| Skilled Ag. Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19020 |
| Mgrs/Prof. Ag Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1039 |
| Ag Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 121009 |
| Unskilled Non Ag. Labor | 439 | 0 | 2927 | 5761 | 17560 | 8581 | 14380 | 69732 | 17662 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 194218 |
| Skilled Non-Ag. Labor | 300 | 0 | 2975 | 14820 | 21623 | 13861 | 15321 | 57650 | 18295 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 206948 |
| Mgrs/Prof. Non-Ag Labor | 53 | 0 | 1069 | 3382 | 9418 | 3890 | 5464 | 25333 | 5909 | 0 | 0 | 0 | 0 | 0 | 38 | 0 | 82875 |
| Non-Ag. Capital | 240 | 50 | 24001 | 43107 | 199946 | 73558 | 64523 | 17921 | 42187 | 0 | 0 | 0 | 0 | 0 | 16319 | 0 | 758179 |
| Rural Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11655 | 0 | 0 | 0 | 0 | 12 | 0 | 78008 |
| Rural Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7625 | 2388 | 0 | 0 | 0 | 0 | 0 | 53410 |
| Rural Workers/Tenant Farmers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2232 | 4995 | 0 | 0 | 0 | 0 | 0 | 19930 |
| Rural Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2022 | 11100 | 0 | 0 | 0 | 98 | 0 | 24729 |
| Urban Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 53077 | 0 | 0 | 0 | 0 | 29 | 0 | 355228 |
| Urban Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24434 | 32070 | 0 | 0 | 0 | 175 | 0 | 193760 |
| Urban Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50795 | 56142 | 0 | 0 | 0 | 0 | 0 | 396073 |
| Urban Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33611 | 20010 | 0 | 0 | 0 | 0 | 0 | 244933 |
| Urban Non-Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31550 | 10595 | 0 | 0 | 0 | 0 | 0 | 221730 |
| Export Agriculture | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 278 | 105705 | 0 | 0 | 146 | 98 | 1704 | 0 | 140721 |
| Traditional Agriculture | 890 | 0 | 12978 | 0 | 0 | 0 | 49 | 3131 | 2009 | 57045 | 0 | 0 | 683 | 8510 | 3180 | 0 | 181316 |
| Livestock | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 261 | 0 | 0 | 0 | 297 | 10243 | 138 | 0 | 57965 |
| Mineral Extraction | 0 | 0 | 51 | 2265 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 669 | 12308 | 0 | 33768 |
| Non-Mineral Extraction | 2610 | 677 | 44491 | 0 | 0 | 0 | 0 | 354 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 0 | 91674 |
| Durable Consumer Goods | 0 | 0 | 54 | 7098 | 132 | 200 | 1605 | 491 | 2042 | 142210 | 0 | 0 | 952 | 14144 | 12575 | 0 | 251840 |
| Non-Durable Consumer Goods | 135 | 707 | 3767 | 351 | 1351 | 71 | 829 | 5544 | 28867 | 318595 | 0 | 0 | 5992 | 969 | 47524 | 0 | 680452 |
| Intermediate Goods | 93 | 485 | 2621 | 69009 | 8452 | 5708 | 9772 | 7594 | 15637 | 324107 | 0 | 0 | 602 | 2642 | 28631 | 0 | 869159 |
| Capital Goods | 0 | 200 | 1614 | 9744 | 430 | 537 | 13334 | 5550 | 12377 | 39687 | 0 | 0 | 1216 | 24032 | 15623 | 0 | 190096 |
| Coal (Coal Steam and Coke) | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 0 | 0 | 8570 | 0 | 0 | 0 | 60 | 0 | 0 | 14875 |
| Bagasse | 0 | 0 | 6396 | 0 | 0 | 0 | 2136 | 0 | 0 | 0 | 0 | 0 | 1100 | 25 | 0 | 0 | 21244 |
| Kerosene | 0 | 0 | 0 | 3 | 0 | 137 | 1545 | 62 | 0 | 3395 | 0 | 0 | 1 | 103 | 505 | 0 | 5893 |
| Oil (diesel, fuel, naphtha) | 0 | 0 | 1917 | 1396 | 0 | 2633 | 16599 | 465 | 0 | 41912 | 0 | 0 | 150 | 1320 | 2244 | 0 | 74665 |
| Gasoline | 0 | 0 | 0 | 0 | 0 | 0 | 2111 | 0 | 0 | 11477 | 0 | 0 | 155 | 513 | 2387 | 0 | 19921 |
| Ethanol-M | 0 | 0 | 0 | 0 | 0 | 0 | 1087 | 0 | 0 | 0 | 0 | 0 | 1773 | 40 | 100 | 0 | 4732 |
| Ethanol-T | 0 | 0 | 0 | 0 | 0 | 0 | 1135 | 0 | 0 | 0 | 0 | 0 | 1702 | 40 | 105 | 0 | 4645 |
| Gas (LPG,city gas, natural gas) | 0 | 0 | 0 | 20 | 0 | 3952 | 0 | 72 | 8 | 10746 | 0 | 0 | 0 | 90 | 29 | 0 | 18652 |
| Electricity | 0 | 0 | 1637 | 1914 | 380 | 9640 | 7979 | 7555 | 1104 | 75802 | 0 | 0 | 0 | 539 | 14 | 0 | 127450 |
| Fuelwood | 0 | 0 | 0 | 373 | 0 | 1883 | 226 | 0 | 0 | 51117 | 0 | 0 | 0 | 38 | 0 | 0 | 61977 |
| Veg. Charcoal | 0 | 0 | 0 | 0 | 0 | 4699 | 0 | 0 | 0 | 24833 | 0 | 0 | 52 | 19 | 1 | 0 | 30109 |
| Other | 0 | 0 | 0 | 0 | 0 | 990 | 2331 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 122 | 0 | 3472 |
| 0 | 0 | 0 | 9950 | 3706 | 380 | 23934 | 35216 | 8154 | 1112 | 227852 | 0 | 0 | 4933 | 2816 | 5507 | 0 | 387635 |
| Civil Construction | 0 | 0 | 243 | 10038 | 14743 | 498 | 2008 | 2154 | 900 | 0 | 0 | 0 | 17 | 170140 | 1956 | 0 | 205529 |
| Financial/Commercial Services | 199 | 437 | 4823 | 5076 | 262177 | 11238 | 8572 | 48539 | 8223 | 10850 | 0 | 0 | 1173 | 11601 | 3963 | 0 | 604921 |
| Commerce | 52 | 133 | 1467 | 371 | 0 | 2254 | 0 | 978 | 0 | 0 | 0 | 0 | 6625 | 8094 | 16242 | 0 | 191461 |
| Transportation/Communication | 159 | 263 | 3903 | 457 | 3429 | 7153 | 13079 | 4892 | 820 | 716100 | 0 | 0 | 2810 | 451 | 16563 | 0 | 953220 |
| Public Services | 7 | 6 | 193 | 49 | 267 | 351 | 219 | 6658 | 464 | 10850 | 274905 | 0 | 13 | 0 | 0 | 0 | 306682 |
| Private Services | 34 | 78 | 963 | 3138 | 8748 | 3611 | 12842 | 16177 | 6066 | 0 | 0 | 0 | 315 | 0 | 32 | 0 | 187604 |
| Carbon Dioxide Pollution | 24833 | 0 | 227852 | 0 | 10850 | 0 | 716100 | 10850 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2397854 |
| Government | 56 | 248 | 1779 | 3166 | 14684 | 5402 | 4738 | 1314 | 3098 | 0 | 0 | 146162 | 0 | 93637 | 0 | 0 | 413984 |
| Indirect Taxes | 0 | 0 | 0 | 23116 | 23781 | 28821 | 25832 | 13159 | 20015 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 171936 |
| Subsidies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25774 | 0 | 0 | 0 | 0 | 25774 |
| Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2267 | 352774 |
| ROW-Current | 9 | 188 | 29964 | 632 | 2127 | 326 | 5434 | 280 | 419 | 0 | 0 | 0 | 0 | 4077 | 0 | 0 | 214429 |
| ROW-Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 651 | 1616 | 0 | 2267 |
| | 30109 | 3472 | 387635 | 208992 | 600478 | 213928 | 984533 | 314643 | 187753 | 2397854 | 412205 | 171936 | 30707 | 355590 | 189972 | 2267 | 12279462 |

Social Accounting Matrix SAM-TECH, Brazil, 1985, Average Expenditures Propensities Matrix



| | | A-unskill | A-skilled | A-mgrs | A-capital | U-unskill | U-skill | U-mgrs | U-capital | R-capitalist | R-sm prod | R-workers | R-mgrs | U-capital | U-mgrs | U-sm prod | U-org lab | U-unorg la | Ag-Export |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | HH1 | HH2 | HH3 | HH4 | HH5 | HH6 | HH7 | HH8 | HH9 | A101 |
| Unskilled Ag. Labor | F1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0053937 |
| Skilled Ag. Labor | F2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.012102 |
| Mgrs/Prof. Ag Labor | F3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001706 |
| Ag.Capital | F4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1688945 |
| Unskilled Non Ag. Labor | F5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Non-Ag. Labor | F6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Non-Ag Labor | F7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-Ag. Capital | F8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Capitalists | HH1 | 0 | 0 | 0 | 0.548232 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Sm. Producers | HH2 | 0.2552404 | 0.4646688 | 0 | 0.273616 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Workers/Tenant Farmers | HH3 | 0.6658446 | 0.4691378 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Mgrs./Prof. | HH4 | 0 | 0.0661935 | 1 | 0.0761183 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Capitalists | HH5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4115106 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Mgrs./Prof. | HH6 | 0 | 0 | 0 | 0 | 0 | 0 | 0.996125 | 0.0784442 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Sm. Producers | HH7 | 0 | 0 | 0 | 0 | 0.0852209 | 0.1801072 | 0 | 0.3215801 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Organized Workers | HH8 | 0 | 0 | 0 | 0 | 0.3864374 | 0.4926976 | 0 | 0.0230094 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Non-Organized Workeirs | HH9 | 0.0789149 | 0 | 0 | 0 | 0.5283417 | 0.3271953 | 0 | 0.0154336 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Export Agriculture | A101 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0000385 | 0.0006928 | 0.0034621 | 0.0002426 | 0.0000479 | 0.0002299 | 0.0006918 | 0.0015841 | 0.0033599 | 0.0015776 |
| Traditional Agriculture | A102 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0028715 | 0.0124509 | 0.024285 | 0.0056614 | 0.0028714 | 0.0053841 | 0.0126643 | 0.0166739 | 0.0234655 | 0.0019755 |
| Livestock | A103 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0008076 | 0.0049616 | 0.0063723 | 0.0020219 | 0.0008107 | 0.0019309 | 0.005042 | 0.006708 | 0.0061201 | 0.0040008 |
| Mineral Extraction | A104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001872 | 0.0002509 | 0 | 0 | 0.0000051 | 0.0001995 | 0.0000572 | 0.0002616 | 0 |
| Non-Mineral Extraction | A105 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Durable Consumer Goods | A106 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0391498 | 0.0345815 | 0.0124937 | 0.0391848 | 0.0391579 | 0.0373416 | 0.0351678 | 0.0247088 | 0.0120597 | 0 |
| Non-Durable Consumer Goods | A107 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.039778 | 0.146246 | 0.2413949 | 0.0713333 | 0.0397716 | 0.0680119 | 0.1487125 | 0.1827193 | 0.2331529 | 0.0030912 |
| Intermediate Goods | A108 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0020639 | 0.005205 | 0.0050176 | 0.0033564 | 0.002055 | 0.0031978 | 0.0052894 | 0.0050299 | 0.0048392 | 0.0275368 |
| Capital Goods | A109 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0002436 | 0.0003557 | 0.0013547 | 0.0002426 | 0.0002505 | 0.0002197 | 0.0003661 | 0.0005675 | 0.0012718 | 0.0003056 |
| Coal (Coal Steam and Coke) | E110-1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bagasse | E110-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kerosene | E110-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0002621 | 0.0015053 | 0 | 0 | 0 | 0.000048 | 0.0000735 | 0.0001578 | 0 |
| Oil (diesel, fuel, naphtha) | E110-4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0025938 |
| Gasoline | E110-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0002692 | 0.0021906 | 0 | 0.0024263 | 0.0036343 | 0.0030701 | 0.0027318 | 0.0004328 | 0 | 0 |
| Ethanol-M | E110-6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0004487 | 0 | 0 | 0.0013749 | 0.0028601 | 0.0018901 | 0.0006994 | 0 | 0 | 0 |
| Ethanol-T | E110-7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0004359 | 0 | 0 | 0.001294 | 0.0027475 | 0.0018134 | 0.0006716 | 0 | 0 | 0 |
| Gas (LPG,city gas, natural gas) | E110-8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0006538 | 0.0022842 | 0.0018063 | 0.001941 | 0.0008839 | 0.0022221 | 0.0035221 | 0.0026252 | 0.0020926 | 0 |
| Electricity | E110-9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0109989 | 0 | 0 | 0 | 0.0029699 | 0.0082754 | 0.0091423 | 0.0050381 | 0.0034141 | 0.0019187 |
| Fuelwood | E110-10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0003589 | 0.0135742 | 0.0046162 | 0.0115249 | 0.0001323 | 0.0004393 | 0.0024011 | 0.0027191 | 0.0034276 | 0.0025938 |
| Veg. Charcoel | E110-11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0006366 | 0.0023583 | 0 | 0 | 0.0000715 | 0.0001363 | 0.0003593 | 0.0010598 | 0 |
| Other | E110-12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Civil Construction | A111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Financial/Commercial Services | A112 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0600708 | 0.1308744 | 0.1530858 | 0.0836265 | 0.0600685 | 0.0796894 | 0.1330841 | 0.1358984 | 0.1478555 | 0.0032049 |
| Commerce | A113 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0465721 | 0.1014791 | 0.1186653 | 0.0648227 | 0.0465701 | 0.0617848 | 0.1031754 | 0.1053553 | 0.1146304 | 0.0003837 |
| Transportation/Communication | A114 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0526869 | 0.1289084 | 0.1548921 | 0.0771159 | 0.0526788 | 0.0735135 | 0.1310819 | 0.1368823 | 0.1496099 | 0.0015776 |
| Public Services | A115 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0045765 | 0.0082194 | 0.0038133 | 0.0058231 | 0.0045717 | 0.0055016 | 0.0082737 | 0.0066794 | 0.0036711 | 0.0000995 |
| Private Services | A116 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0659035 | 0.0945329 | 0.047416 | 0.0774394 | 0.0658901 | 0.0738149 | 0.0961237 | 0.0639522 | 0.0457719 | 0.0017695 |
| Carbon Dioxide Pollution | CO2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1494078 | 0.1427635 | 0.111992 | 0.0817663 | 0.1494167 | 0.1248161 | 0.1282466 | 0.1372253 | 0.1422902 | 0.7511672 |
| Sum of Endogenous Accounts | Sum | 0.9999999 | 1.0000001 | 1 | 0.8979663 | 1 | 1.0000001 | 0.996125 | 0.8499779 | 0.4773359 | 0.8304061 | 0.8947818 | 0.531198 | 0.4773889 | 0.5532232 | 0.8274714 | 0.8352896 | 0.8985116 | 0.990357 |
| Government | G | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1141934 | 0.0487175 | 0.0317612 | 0.1116099 | 0.1141408 | 0.1063598 | 0.0495464 | 0.048548 | 0.030695 | 0.0071134 |
| Indirect Taxes | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0024659 |
| Subsidies | S | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Capital | DKF | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4043944 | 0.1208762 | 0.0734571 | 0.3527437 | 0.404391 | 0.3361667 | 0.1229824 | 0.1161624 | 0.0707933 | 0 |
| ROW-Current | ROW-C | 0 | 0 | 0 | 0.1020337 | 0 | 0 | 0.093875 | 0.1500222 | 0.0040765 | 0 | 0 | 0.0044482 | 0.0040791 | 0.0042501 | 0 | 0 | 0 | 0.000064 |
| ROW-Capital | ROW-K | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Column Total | | 0.9999999 | 1.0000001 | 1 | 1 | 1 | 1.0000001 | 1 | 1.0000001 | 1.0000002 | 0.9999998 | 1.0000001 | 0.9999998 | 0.9999998 | 0.9999998 | 1.0000002 | 1 | 0.9999999 | 1.0000003 |

Social Accounting Matrix SAM-TECH, Brazil, 1985, Average Expenditures Propensities Matrix



| | Ag-Trad A102 | Livestock A103 | Minerals A104 | Non-min A105 | Cons-Dur A106 | Con-ND A107 | Intermed A108 | Capital A109 | Coal E110-1 | Bagasse E110-2 | Kerosene E110-3 | Oil E110-4 | Gasoline E110-5 | Ethanol-M E110-6 | Ethanol-T E110-7 | Gas E110-8 | Electricity E110-9 | Fuelwood E110-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unskilled Ag. Labor | 0.0098374 | 0.0562753 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Ag. Labor | 0.0456997 | 0.1660312 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Ag Labor | 0.005281 | 0.0021737 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ag Capital | 0.4175647 | 0.4649357 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unskilled Non Ag. Labor | 0 | 0 | 0.0189222 | 0.0581565 | 0.0202632 | 0.0159853 | 0.0275152 | 0.0612472 | 0.0196303 | 0.0197333 | 0.04972 | 0.0020069 | 0.0147081 | 0.0211327 | 0.0729817 | 0.0157088 | 0.0023289 | 0.0023573 |
| Skilled Non-Ag. Labor | 0 | 0 | 0.0649227 | 0.1861476 | 0.024779 | 0.025189 | 0.0170587 | 0.0551246 | 0.0134454 | 0.0168373 | 0.0492109 | 0.0046737 | 0.0198283 | 0.0253593 | 0.0516685 | 0.0176925 | 0.0030998 | 0.0019375 |
| Mgrs/Prof. Non-Ag Labor | 0 | 0 | 0.0092535 | 0.0248395 | 0.0101316 | 0.0057397 | 0.0153277 | 0.0323744 | 0.0076639 | 0.0035695 | 0.0089937 | 0.0028454 | 0.0053712 | 0.0173288 | 0.0053821 | 0.0057367 | 0.0017089 | 0.0008557 |
| Non-Ag. Capital | 0 | 0 | 0.4990361 | 0.4067143 | 0.0791545 | 0.1038681 | 0.1180283 | 0.126845 | 0.1483025 | 0.0774515 | 0.0700831 | 0.0822153 | 0.1204759 | 0.1407439 | 0.126803 | 0.0922153 | 0.0663365 | 0.003875 |
| Rural Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Workers/Tenant Farmers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Non-Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Export Agriculture | 0.0028217 | 0.0033814 | 0 | 0.0000636 | 0.0105963 | 0.0392664 | 0.0012302 | 0.0000265 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Traditional Agriculture | 0.0475413 | 0.0690762 | 0.0005339 | 0 | 0.0001628 | 0.0599703 | 0.0114629 | 0.0000265 | 0 | 0.3459052 | 0 | 0 | 0 | 0.6747676 | 0.6251884 | 0 | 0 | 0.0138048 |
| Livestock | 0.0125521 | 0.0166652 | 0 | 0 | 0 | 0.0545498 | 0.0003104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mineral Extraction | 0.0025069 | 0.0046925 | 0.0634695 | 0.0010385 | 0.0005004 | 0.0030206 | 0.0148522 | 0.0017721 | 0.0034286 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-Mineral Extraction | 0 | 0 | 0.0002373 | 0.0010173 | 0.0000556 | 0.0000177 | 0.0025515 | 0.000069 | 0.0972101 | 0.0167699 | 0 | 0.0001787 | 0.1976808 | 0 | 0 | 0.1219708 | 0.2051457 | 0.1206588 |
| Durable Consumer Goods | 0 | 0.0018632 | 0.002432 | 0.0008054 | 0.0646779 | 0.001132 | 0.0014945 | 0.009099 | 0.0036303 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-Durable Consumer Goods | 0.002691 | 0.0019322 | 0.0028472 | 0.0023949 | 0.0018111 | 0.0792717 | 0.0077065 | 0.0029552 | 0.0227899 | 0 | 0.01103 | 0.0056496 | 0.0104412 | 0.0169062 | 0.0163617 | 0.0071306 | 0.0103487 | 0.0050214 |
| Intermediate Goods | 0.0587568 | 0.1446735 | 0.061601 | 0.0511201 | 0.0761877 | 0.0741305 | 0.2857001 | 0.2219204 | 0.0157311 | 0 | 0.0076362 | 0.0042063 | 0.0071784 | 0.011623 | 0.0114101 | 0.0049324 | 0.0071614 | 0.0034552 |
| Capital Goods | 0.0014613 | 0.0009834 | 0.0360649 | 0.0598733 | 0.068872 | 0.0042309 | 0.0124322 | 0.1496429 | 0.0132437 | 0 | 0 | 0.0024056 | 0.0044676 | 0.0114117 | 0.0109795 | 0.0027879 | 0.0051346 | 0.0024219 |
| Coal (Coal Steam and Coke) | 0 | 0 | 0 | 0 | 0 | 0.0000635 | 0.0064913 | 0.0027058 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bagasse | 0 | 0 | 0 | 0 | 0 | 0 | 0.0059905 | 0 | 0 | 0.4307651 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kerosene | 0 | 0 | 0 | 0 | 0 | 0.0000207 | 0 | 0.0000637 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oil (diesel, fuel, naphtha) | 0.0057028 | 0.0011559 | 0.0180028 | 0.0054469 | 0 | 0.0007685 | 0.0012244 | 0.001459 | 0 | 0 | 0 | 0.0263512 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gasoline | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ethanol-M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ethanol-T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gas (LPG,city gas, natural gas) | 0 | 0 | 0 | 0.001971 | 0 | 0.0000547 | 0.0000796 | 0.0001486 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Electricity | 0.0035643 | 0.007677 | 0.0250912 | 0.002183 | 0.0043728 | 0.0037994 | 0.0038383 | 0.0044673 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0130114 | 0 |
| Fuelwood | 0.0051919 | 0.0137497 | 0.0016312 | 0 | 0 | 0.0016019 | 0.0017599 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Veg. Charcoal | 0 | 0 | 0.0009787 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Civil Construction | 0 | 0.0000863 | 0.0026396 | 0.0061251 | 0.0009133 | 0.0009532 | 0.0011113 | 0.0019259 | 0.0028908 | 0 | 0 | 0 | 0 | 0.009721 | 0.0094726 | 0 | 0.0008743 | 0 |
| Financial/Commercial Services | 0.0080552 | 0.0025878 | 0.0585461 | 0.0906682 | 0.0214944 | 0.0190074 | 0.0226545 | 0.0277745 | 0.0156639 | 0.0190598 | 0.0225691 | 0.0059658 | 0.0132523 | 0.021344 | 0.0208827 | 0.0091143 | 0.0165007 | 0.0063938 |
| Commerce | 0.000802 | 0.0012249 | 0.0146217 | 0.0080537 | 0.0101118 | 0.0090943 | 0.0088105 | 0.0144948 | 0.0088739 | 0.0095636 | 0.0042423 | 0.0021581 | 0.0040661 | 0.0065511 | 0.0064586 | 0.0037879 | 0.0040616 | 0.0019537 |
| Transportation/Communication | 0.0033385 | 0.0050375 | 0.0129312 | 0.0082021 | 0.0055404 | 0.0050363 | 0.004743 | 0.0060324 | 0.0235966 | 0.0210129 | 0.0288478 | 0.0085501 | 0.0107926 | 0.0175402 | 0.0170075 | 0.0122239 | 0.0084332 | 0.0058125 |
| Public Services | 0.0002257 | 0.0005521 | 0.0032624 | 0.0025433 | 0.0006831 | 0.0008556 | 0.0020207 | 0.0013794 | 0.0011429 | 0.0010102 | 0.0005091 | 0.0006048 | 0.0005522 | 0.0008453 | 0.0008611 | 0.0005361 | 0.0004451 | 0.0002583 |
| Private Services | 0.0037425 | 0.0056413 | 0.0269597 | 0.0251998 | 0.0091308 | 0.0080303 | 0.0076027 | 0.0123778 | 0.0058487 | 0.0051859 | 0.0028848 | 0.0018007 | 0.0026605 | 0.0042265 | 0.0043057 | 0.0018229 | 0.0026388 | 0.0012917 |
| Carbon Dioxide Pollution | 0.3388718 | 0 | 0 | 0 | 0.564805 | 0.4708173 | 0.3740251 | 0.2105612 | 0.5761344 | 0 | 0.5761073 | 0.5761258 | 0.5761257 | 0 | 0 | 0.5761312 | 0.6024973 | 0.825333 |
| Sum of Endogenous Accounts | 0.9762086 | 0.970396 | 0.9239849 | 0.9425641 | 0.9742637 | 0.9864751 | 0.9560422 | 0.9444932 | 0.979227 | 0.9668642 | 0.8318343 | 0.725738 | 0.9876009 | 0.9795013 | 0.9797632 | 0.8707913 | 0.9497269 | 0.9954306 |
| Government | 0.0175956 | 0.0195808 | 0.0366284 | 0.0298625 | 0.0058145 | 0.0076269 | 0.0086678 | 0.0093165 | 0.0114286 | 0.0061961 | 0.0054302 | 0.0024743 | 0.0051704 | 0.0084531 | 0.0081808 | 0.0039138 | 0.0051823 | 0.0015339 |
| Indirect Taxes | 0.0060295 | 0.0097473 | 0.037963 | 0.0232711 | 0.0154298 | 0 | 0.0257138 | 0.0357594 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subsidies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ROW-Current | 0.0001663 | 0.000276 | 0.0014236 | 0.0043024 | 0.0044919 | 0.0058979 | 0.009576 | 0.0104307 | 0.0093445 | 0.0269397 | 0.1627354 | 0.2717876 | 0.0072286 | 0.0120456 | 0.012056 | 0.1252949 | 0.0450907 | 0.0030354 |
| ROW-Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Column Total | 1 | 1.0000001 | 0.9999999 | 1.0000001 | 0.9999999 | 0.9999999 | 0.9999998 | 0.9999998 | 1.0000001 | 1 | 0.9999999 | 0.9999999 | 0.9999999 | 1 | 1 | 1 | 0.9999999 | 0.9999999 |

Appendix 3. Social Accounting Matrix SAM-TECH, Brazil, 1985, Average Expenditures Propensities Matrix



| | Veg. Char E110-11 | Other E110-12 | Construct A111 | Financial A112 | Commerce A113 | Transport A114 | Public A115 | Private A116 | CO2 CO2 | Gov't G | Ind. Taxes T | Subsidies S | Capital DKF | ROW-Cur ROW-C | ROW-Cap ROW-K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unskilled Ag. Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Ag. Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Ag Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ag Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unskilled Non Ag. Labor | 0.0145804 | 0 | 0.0280633 | 0.0292619 | 0.0451646 | 0.0151477 | 0.2275188 | 0.0946309 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Non-Ag. Labor | 0.0099638 | 0 | 0.072192 | 0.0360324 | 0.0729549 | 0.016139 | 0.1880981 | 0.0980224 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Non-Ag Labor | 0.0017603 | 0 | 0.0164746 | 0.0156941 | 0.0204743 | 0.0057557 | 0.0826555 | 0.0316597 | 0 | 0 | 0 | 0 | 0 | 0.000206 | 0 |
| Non-Ag. Capital | 0.007971 | 0.0142288 | 0.2099851 | 0.3331889 | 0.3871596 | 0.0679678 | 0.0584719 | 0.2260329 | 0 | 0 | 0 | 0 | 0 | 0.0895509 | 0 |
| Rural Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.005371 | 0 | 0 | 0 | 0 | 0.0000651 | 0 |
| Rural Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0035138 | 0.0057932 | 0 | 0 | 0 | 0 | 0 |
| Rural Workers/Tenant Farmers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0010286 | 0.0121178 | 0 | 0 | 0 | 0 | 0 |
| Rural Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0009318 | 0.0269283 | 0 | 0 | 0 | 0.0005313 | 0 |
| Urban Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0244594 | 0 | 0 | 0 | 0 | 0.0001572 | 0 |
| Urban Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0112599 | 0.0778011 | 0 | 0 | 0 | 0.0009487 | 0 |
| Urban Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0234078 | 0.1361992 | 0 | 0 | 0 | 0 | 0 |
| Urban Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0154889 | 0.0485438 | 0 | 0 | 0 | 0 | 0 |
| Urban Non-Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0145392 | 0.0257032 | 0 | 0 | 0 | 0 | 0 |
| Export Agriculture | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0014895 | 0.0487119 | 0 | 0 | 0.0056646 | 0.0002778 | 0.0092375 | 0 |
| Traditional Agriculture | 0.0295593 | 0 | 0 | 0 | 0 | 0.0000516 | 0.0102157 | 0.010764 | 0.026288 | 0 | 0 | 0.0264996 | 0.0241231 | 0.017239 | 0 |
| Livestock | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001109 | 0.0013984 | 0 | 0 | 0 | 0.0115232 | 0.0290356 | 0.0007481 | 0 |
| Mineral Extraction | 0 | 0 | 0.0110334 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0018964 | 0.0667227 | 0 |
| Non-Mineral Extraction | 0.086685 | 0.1926579 | 0 | 0 | 0 | 0 | 0.001155 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001735 | 0 |
| Durable Consumer Goods | 0 | 0 | 0.0345762 | 0.00022 | 0.0010527 | 0.0016907 | 0.001602 | 0.0109408 | 0.0655345 | 0 | 0 | 0.0369364 | 0.0400937 | 0.0681701 | 0 |
| Non-Durable Consumer Goods | 0.0044837 | 0.2011952 | 0.0017098 | 0.0022513 | 0.0003737 | 0.0008733 | 0.0180887 | 0.1546659 | 0.1468178 | 0 | 0 | 0.2324823 | 0.0027468 | 0.2576315 | 0 |
| Intermediate Goods | 0.0030888 | 0.1380194 | 0.3361603 | 0.0140844 | 0.0300431 | 0.0102937 | 0.0247774 | 0.0837812 | 0.1493579 | 0 | 0 | 0.0233569 | 0.0074892 | 0.155211 | 0 |
| Capital Goods | 0 | 0.0569152 | 0.0474655 | 0.0007165 | 0.0028264 | 0.0140459 | 0.0181083 | 0.0663145 | 0.0182889 | 0 | 0 | 0.0471793 | 0.0681229 | 0.0846936 | 0 |
| Coal (Coal Steam and Coke) | 0 | 0 | 0 | 0 | 0 | 0.0000706 | 0 | 0 | 0.0039493 | 0 | 0 | 0 | 0.0001701 | 0 | 0 |
| Bagasse | 0 | 0 | 0 | 0 | 0 | 0.00225 | 0 | 0 | 0 | 0 | 0 | 0.0426787 | 0.0000709 | 0 | 0 |
| Kerosene | 0 | 0 | 0.0000146 | 0 | 0.0007211 | 0.0016275 | 0.0002023 | 0 | 0.0015645 | 0 | 0 | 0.0000388 | 0.000292 | 0.0027376 | 0 |
| Oil (diesel, fuel, naphtha) | 0 | 0 | 0.0068003 | 0 | 0.0138583 | 0.0174852 | 0.0015172 | 0 | 0.0193143 | 0 | 0 | 0.0058198 | 0.0037418 | 0.0121649 | 0 |
| Gasoline | 0 | 0 | 0 | 0 | 0 | 0.0022237 | 0 | 0 | 0.0052889 | 0 | 0 | 0.0060138 | 0.0014542 | 0.0129401 | 0 |
| Ethanol-M | 0 | 0 | 0 | 0 | 0 | 0.001145 | 0 | 0 | 0 | 0 | 0 | 0.0687903 | 0.0001134 | 0.0005421 | 0 |
| Ethanol-T | 0 | 0 | 0 | 0 | 0 | 0.0011956 | 0 | 0 | 0 | 0 | 0 | 0.0660355 | 0.0001134 | 0.0005692 | 0 |
| Gas (LPG,city gas, natural gas) | 0 | 0 | 0.0000974 | 0 | 0.0208007 | 0 | 0.0002349 | 0.0000429 | 0.0049521 | 0 | 0 | 0 | 0.0002551 | 0.0001572 | 0 |
| Electricity | 0 | 0 | 0.0093236 | 0.0006332 | 0.0507384 | 0.008405 | 0.0246502 | 0.0059151 | 0.0349318 | 0 | 0 | 0 | 0.0015279 | 0.0000759 | 0 |
| Fuelwood | 0 | 0 | 0.001817 | 0 | 0.0099108 | 0.0002381 | 0 | 0 | 0.0235562 | 0 | 0 | 0 | 0.0001077 | 0 | 0 |
| Veg. Charcoal | 0 | 0 | 0 | 0 | 0.0247324 | 0 | 0 | 0 | 0.0114438 | 0 | 0 | 0.0020175 | 0.0000539 | 0.0000054 | 0 |
| Other | 0 | 0 | 0 | 0 | 0.0052107 | 0.0024554 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0000822 | 0.0006614 | 0 |
| Civil Construction | 0 | 0 | 0.0488976 | 0.0245677 | 0.0026211 | 0.0021152 | 0.007028 | 0.0048221 | 0 | 0 | 0 | 0.0006596 | 0.4822918 | 0.0106036 | 0 |
| Financial/Commercial Services | 0.0066093 | 0.1243597 | 0.0247265 | 0.4368903 | 0.0591492 | 0.0090297 | 0.1583711 | 0.0440578 | 0.005 | 0 | 0 | 0.045511 | 0.0328851 | 0.0214838 | 0 |
| Commerce | 0.0017271 | 0.0378486 | 0.0018072 | 0 | 0.0118635 | 0 | 0.003191 | 0 | 0 | 0 | 0 | 0.257042 | 0.0229439 | 0.0880492 | 0 |
| Transportation/Communication | 0.0052808 | 0.0748435 | 0.0022262 | 0.0057141 | 0.0376486 | 0.0137773 | 0.0159614 | 0.0043935 | 0.3299997 | 0 | 0 | 0.1090246 | 0.0012784 | 0.0897894 | 0 |
| Public Services | 0.0002325 | 0.0017075 | 0.0002387 | 0.0004449 | 0.0018474 | 0.0002307 | 0.0217235 | 0.0024861 | 0.005 | 0.6669133 | 0 | 0.0005044 | 0 | 0 | 0 |
| Private Services | 0.0011292 | 0.0221969 | 0.015286 | 0.0145776 | 0.0190059 | 0.0135276 | 0.0527817 | 0.0325009 | 0 | 0 | 0 | 0.0122216 | 0 | 0.0001735 | 0 |
| Carbon Dioxide Pollution | 0.82477 | 0 | 0 | 0.0180804 | 0 | 0.7543318 | 0.0354009 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum of Endogenous Accounts | 0.9978412 | 0.8639727 | 0.8688953 | 0.9323577 | 0.8181574 | 0.9620738 | 0.9518645 | 0.8739186 | 1 | 0.9999999 | 0 | 0.9999999 | 0.7211673 | 0.9912395 | 0 |
| Government | 0.0018599 | 0.0705748 | 0.0154224 | 0.0244693 | 0.0284325 | 0.004991 | 0.0042873 | 0.0165987 | 0 | 0 | 0.8500954 | 0 | 0.2654306 | 0 | 0 |
| Indirect Taxes | 0 | 0 | 0.1126039 | 0.0396285 | 0.1516943 | 0.0272111 | 0.0429347 | 0.107238 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subsidies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1499046 | 0 | 0 | 0 | 0 |
| Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| ROW-Current | 0.0002989 | 0.0654525 | 0.0030786 | 0.0035444 | 0.0017158 | 0.0057241 | 0.0009136 | 0.002245 | 0 | 0 | 0 | 0 | 0.011557 | 0 | 0 |
| ROW-Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0018454 | 0.0087605 | 0 |
| Column Total | 1 | 1 | 1.0000002 | 0.9999999 | 1 | 1 | 1.0000001 | 1.0000003 | 1 | 0.9999999 | 1 | 0.9999999 | 1.0000003 | 1 | 1 |

Appendix 4. 'Finalized Household Marginal Expenditures Propensities

| | Rural Capitalists HH1 | Rural Sm. Producers HH2 | Rural Workers Tenant Farmers HH3 | Rural Mgrs./Prof. HH4 | Urban Capitalists HH5 | Urban Mgrs./Prof. HH6 | Urban Sm. Producers HH7 | Urban Lab. Urban Organized HH8 | Urban Lab. Non-Organized HH9 |
|---|---|---|---|---|---|---|---|---|---|
| Export Agriculture | 5.288E-08 | 1.1884E-05 | 0.000315181 | 1.937E-06 | 8.577E-08 | 1.922E-06 | 1.297E-05 | 7.55141E-05 | 0.000360031 |
| Traditional Agriculture | 0.000202 | 0.00118419 | 0.00811493 | 0.0003084 | 0.0001985 | 0.0005793 | 0.0028052 | 0.004486726 | 0.012434704 |
| Livestock | 1.525E-05 | 0.00022158 | 0.000593245 | 3.27E-05 | 1.513E-05 | 7.342E-05 | 0.0004571 | 0.000821234 | 0.000797985 |
| Mineral Extraction | 0 | 7.3277E-07 | 8.26955E-07 | 0 | 0 | 4.542E-10 | 1.043E-06 | 2.16266E-08 | 1.7195E-06 |
| Non-Mineral Extraction | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Durable Consumer Goods | 0.0331252 | 0.01748403 | 9.6305E-05 | 0.0248465 | 0.0323778 | 0.0259929 | 0.0180786 | 0.011977326 | 0.001722921 |
| Non-Durable Consumer Goods | 0.0287679 | 0.16269434 | 0.276933039 | 0.0781701 | 0.0295745 | 0.0585918 | 0.1188576 | 0.183987776 | 0.210589644 |
| Intermediate Goods | 7.341E-05 | 0.00015038 | 0.000208723 | 5.428E-05 | 6.963E-05 | 0.0001376 | 0.0003822 | 0.000311574 | 0.000372822 |
| Capital Goods | 1.166E-05 | 3.9687E-05 | 5.15819E-05 | 2.272E-05 | 1.231E-05 | 1.37E-05 | 2.619E-05 | 4.90052E-05 | 4.84479E-05 |
| Coal (Coal Steam and Coke) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bagasse | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kerosene | 0 | 1.1322E-05 | 0.00172691 | 0 | 0 | 0 | 8.122E-06 | 2.49194E-07 | 5.34506E-06 |
| Oil (diesel, fuel, naptha) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gasoline | 5.666E-05 | 9.4629E-05 | 0 | 0.0002383 | 0.0007326 | 0.0006476 | 0.0004623 | 1.46736E-06 | 0 |
| Alcohol | 9.444E-05 | 0 | 0 | 0.000135 | 0.0005765 | 0.0003987 | 0.0001184 | 0 | 0 |
| Alcohol | 9.174E-05 | 0 | 0 | 0.0001271 | 0.0005538 | 0.0003825 | 0.0001136 | 0 | 0 |
| Gas (LPG,city gas, natural gas) | 0.0001376 | 9.8672E-05 | 0.002072223 | 0.0001906 | 0.0001782 | 0.0004687 | 0.000596 | 8.90046E-06 | 7.08813E-05 |
| Electricity | 0.0023149 | 0 | 0 | 0 | 0.0005986 | 0.0017456 | 0.001547 | 1.70811E-05 | 0.000115644 |
| Fuelwood | 7.554E-05 | 0.00058637 | 0.005295797 | 0.0011319 | 2.667E-05 | 9.266E-05 | 0.0004063 | 9.21882E-06 | 0.000116101 |
| Veg. Charcoal | 0 | 2.75E-05 | 0.002705489 | 0 | 0 | 0 | 2.306E-05 | 1.21817E-06 | 3.58979E-05 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Civil Construction | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Financial/Commercial Services | 0.0434438 | 0.14559389 | 0.17562308 | 0.0916416 | 0.0446674 | 0.0686519 | 0.1063667 | 0.136841835 | 0.133546858 |
| Commerce | 0.0416682 | 0.04533418 | 0.094848654 | 0.0230795 | 0.040428 | 0.0545363 | 0.1426939 | 0.125101446 | 0.212676658 |
| Transportation/Communication | 0.0381037 | 0.14340677 | 0.177695303 | 0.084507 | 0.0391724 | 0.0633314 | 0.1047665 | 0.137832566 | 0.135131476 |
| Public Services | 0.0033098 | 0.00914384 | 0.004374694 | 0.0063812 | 0.0033995 | 0.0047396 | 0.0066127 | 0.00672577 | 0.003315831 |
| Private Services | 0.1364362 | 0.161559 | 0.032134019 | 0.1385631 | 0.1353922 | 0.1479803 | 0.1948896 | 0.089815071 | 0.044878034 |
| | 0.327928 | 0.687643 | 0.78279 | 0.449432 | 0.327974 | 0.428366 | 0.699225 | 0.698064 | 0.756221 |
| | 0.327928 | 0.687643 | 0.78279 | 0.449432 | 0.327974 | 0.428366 | 0.699225 | 0.698064 | 0.756221 |

Appendix 5. Social Accounting Matrix SAM-TECH, Brazil, 1985, Marginal Expenditures Propensities Matrix



| | | A-unskill | A-skilled | A-mgrs | A-capital | U-unskill | U-skill | U-mgrs | U-capital | R-capitalis | R-sm prod | R-workers | R-mgrs | U-capital | U-mgrs | U-sm prod | U-org lab | U-unorg la | Ag-Export |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | HH1 | HH2 | HH3 | HH4 | HH5 | HH6 | HH7 | HH8 | HH9 | A101 |
| Unskilled Ag. Labor | F1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00539 |
| Skilled Ag. Labor | F2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 0121 |
| Mgrs/Prof. Ag Labor | F3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00017 |
| Ag Capital | F4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 16689 |
| Unskilled Non Ag. Labor | F5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Non-Ag. Labor | F6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Non-Ag Labor | F7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-Ag. Capital | F8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Capitalists | HH1 | 0 | 0 | 0 | 0 54823 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Sm. Producers | HH2 | 0 25524 | 0 46467 | 0 | 0 27362 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Workers/Tenant Farmers | HH3 | 0 66584 | 0 46914 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Mgrs./Prof. | HH4 | 0 | 0 06619 | 1 | 0 07612 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Capitalists | HH5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 41151 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Mgrs./Prof. | HH6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 99612 | 0 07844 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Sm. Producers | HH7 | 0 | 0 | 0 | 0 | 0 08522 | 0.18011 | 0 | 0 32158 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Organized Workers | HH8 | 0 | 0 | 0 | 0 | 0 38644 | 0 4927 | 0 | 0 02301 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Non-Organized Workers | HH9 | 0 07891 | 0 | 0 | 0 | 0 52834 | 0 3272 | 0 | 0 01543 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Export Agriculture | A101 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00005 | 0 00001 | 0 00032 | 0 | 0 | 0 | 0 00001 | 0 00008 | 0 00036 | 0 00158 |
| Traditional Agriculture | A102 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 0002 | 0 00118 | 0.00811 | 0 00031 | 0 0002 | 0 00058 | 0 00281 | 0 00449 | 0 01243 | 0 00198 |
| Livestock | A103 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00002 | 0 00022 | 0 00059 | 0 00003 | 0 00002 | 0 00007 | 0 00048 | 0 00082 | 0.0008 | 0 004 |
| Mineral Extraction | A104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-Mineral Extraction | A105 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Durable Consumer Goods | A106 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 03312 | 0 01748 | 0 0001 | 0 02485 | 0 03238 | 0 02599 | 0 01808 | 0 01198 | 0 00172 | 0 |
| Non-Durable Consumer Goods | A107 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 02877 | 0 18269 | 0.27693 | 0 07817 | 0 02957 | 0.05859 | 0 11888 | 0 18399 | 0 21059 | 0 00309 |
| Intermediate Goods | A108 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00007 | 0 00015 | 0 00021 | 0 00005 | 0 00007 | 0 0032 | 0 00038 | 0 00031 | 0 00037 | 0 02754 |
| Capital Goods | A109 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00001 | 0.00004 | 0 00005 | 0 00002 | 0 00001 | 0 00001 | 0 00003 | 0 00005 | 0 00005 | 0 00031 |
| Coal (Coal Steam and Coke) | E110 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bagasse | E110 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kerosene | E110 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00001 | 0 00173 | 0 | 0 | 0 | 0 00001 | 0 | 0 00001 | 0 |
| Oil (diesel, fuel, naphtha) | E110 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00259 |
| Gasoline | E110 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00006 | 0 00009 | 0 | 0 00024 | 0 00073 | 0 00065 | 0 00048 | 0 | 0 | 0 |
| Alcohol | E110 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00009 | 0 | 0 | 0 00013 | 0 00058 | 0 0004 | 0 00012 | 0 | 0 | 0 |
| Alcohol | E110 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00009 | 0 | 0 | 0 00013 | 0 00055 | 0 00038 | 0 00011 | 0 | 0 | 0 |
| Gas (LPG,city gas, natural gas) | E110 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00014 | 0 0001 | 0 00207 | 0.00019 | 0.00018 | 0.00047 | 0 0008 | 0 00001 | 0 00007 | 0 |
| Electricity | E110 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00231 | 0 | 0 | 0 | 0 0008 | 0 00175 | 0 00155 | 0.00002 | 0 00012 | 0 00192 |
| Fuelwood | E110 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00008 | 0 00059 | 0 0053 | 0 00113 | 0.00003 | 0 00009 | 0.00041 | 0 00001 | 0 00012 | 0 00259 |
| Veg. Charcoal | E110 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00003 | 0 00271 | 0 | 0 | 0 | 0.00002 | 0 | 0 00004 | 0 |
| Other | E110 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Civil Construction | A111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Financial/Commercial Services | A112 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 04344 | 0 14559 | 0 17582 | 0 09184 | 0 04487 | 0 06865 | 0.10637 | 0 13684 | 0 13355 | 0.0032 |
| Commerce | A113 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 04187 | 0.04533 | 0 09485 | 0 02308 | 0 04043 | 0.05454 | 0 14269 | 0 1251 | 0 21268 | 0 00038 |
| Transportation/Communication | A114 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0381 | 0.14341 | 0 1777 | 0 08451 | 0 03917 | 0 06333 | 0.10477 | 0 13783 | 0 13513 | 0 00158 |
| Public Services | A115 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00331 | 0 00914 | 0 00437 | 0.00638 | 0.0034 | 0 00474 | 0 00661 | 0 00673 | 0.00332 | 0.0001 |
| Private Services | A116 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 13644 | 0 16158 | 0 03213 | 0.13858 | 0.13539 | 0 14798 | 0 19489 | 0 08981 | 0 04488 | 0 00177 |
| Carbon Dioxide Pollution | CO2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.14941 | 0 14276 | 0 11199 | 0 08177 | 0 14942 | 0 12483 | 0 12825 | 0 13723 | 0 14229 | 0 75117 |
| Government | G | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.11419 | 0 04872 | 0 03176 | 0.11161 | 0 11414 | 0 10637 | 0.04955 | 0 04855 | 0.03069 | 0 00711 |
| Indirect Taxes | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 00247 |
| Subsidies | S | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Capital | DKF | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 40439 | 0.12088 | 0 07348 | 0 35274 | 0 40439 | 0 33819 | 0 12298 | 0 11618 | 0 07079 | 0 |
| ROW-Current | ROW-C | 0 | 0 | 0 | 0 10203 | 0 | 0 | 0 00388 | 0 15002 | 0 00408 | 0 | 0 | 0 00445 | 0 00407 | 0 00425 | 0 | 0 | 0 | 0 00006 |
| ROW-Capital | ROW-K | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Social Accounting Matrix SAM-TECH, Brazil, 1985, Marginal Expenditures Propensities Matrix



| | Ag-Trad | Livestock | Minerals | Non-min | Cons-Dur | Con-ND | Intermed. | Capital | Coal | Bagasse | Kerosene | Oil | Gasoline | Ethanol-M | Ethanol-T | Gas | Electricity | Fuelwood |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A102 | A103 | A104 | A105 | A106 | A107 | A108 | A109 | E110.1 | E110.2 | E110.3 | E110.4 | E110.5 | E110.6 | E110.7 | E110.8 | E110.9 | E110.10 |
| Unskilled Ag. Labor | 0.00984 | 0.05628 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Ag. Labor | 0.0457 | 0.16603 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Ag Labor | 0.00528 | 0.00217 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ag Capital | 0.41756 | 0.46494 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unskilled Non Ag. Labor | 0 | 0 | 0.01692 | 0.05816 | 0.02026 | 0.01599 | 0.02752 | 0.06125 | 0.01963 | 0.01973 | 0.04972 | 0.00201 | 0.01471 | 0.02113 | 0.07296 | 0.01571 | 0.00233 | 0.00236 |
| Skilled Non-Ag. Labor | 0 | 0 | 0.06492 | 0.18615 | 0.02478 | 0.02519 | 0.01706 | 0.05512 | 0.01345 | 0.01684 | 0.04921 | 0.00467 | 0.01983 | 0.02536 | 0.05167 | 0.01769 | 0.0031 | 0.00194 |
| Mgrs/Prof. Non-Ag Labor | 0 | 0 | 0.00925 | 0.02484 | 0.01013 | 0.00574 | 0.01533 | 0.03237 | 0.00766 | 0.00357 | 0.00899 | 0.00285 | 0.00537 | 0.01733 | 0.00538 | 0.00574 | 0.00171 | 0.00066 |
| Non-Ag. Capital | 0 | 0 | 0.49904 | 0.40671 | 0.07915 | 0.10387 | 0.11603 | 0.12685 | 0.1483 | 0.07745 | 0.07008 | 0.08222 | 0.12048 | 0.14074 | 0.1268 | 0.09222 | 0.06634 | 0.00387 |
| Rural Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Workers/Tenant Farmers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rural Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Mgrs./Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Urban Non-Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Export Agriculture | 0.00282 | 0.00338 | 0 | 0.00006 | 0.0106 | 0.03927 | 0.00123 | 0.00003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Traditional Agriculture | 0.04754 | 0.06908 | 0.00053 | 0 | 0.00016 | 0.05997 | 0.01146 | 0.00003 | 0 | 0.34591 | 0 | 0 | 0 | 0.67477 | 0.62519 | 0 | 0 | 0.0138 |
| Livestock | 0.01255 | 0.01667 | 0 | 0 | 0 | 0.05455 | 0.00031 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mineral Extraction | 0.00251 | 0.00469 | 0.06347 | 0.00104 | 0.0005 | 0.00302 | 0.01465 | 0.00177 | 0.00343 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-Mineral Extraction | 0 | 0 | 0.00024 | 0.00102 | 0.00006 | 0.00002 | 0.00255 | 0.00007 | 0.09721 | 0.01677 | 0 | 0.00018 | 0.19768 | 0 | 0 | 0.12197 | 0.20515 | 0.12058 |
| Durable Consumer Goods | 0 | 0.00166 | 0.00243 | 0.00081 | 0.06468 | 0.00113 | 0.00149 | 0.0091 | 0.00363 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-Durable Consumer Goods | 0.00269 | 0.00193 | 0.00285 | 0.00239 | 0.00181 | 0.07927 | 0.00771 | 0.00298 | 0.02279 | 0 | 0.01103 | 0.00565 | 0.01044 | 0.01691 | 0.01636 | 0.00713 | 0.01035 | 0.00502 |
| Intermediate Goods | 0.05876 | 0.14467 | 0.0616 | 0.05112 | 0.07619 | 0.07413 | 0.2857 | 0.22192 | 0.01573 | 0 | 0.00764 | 0.00421 | 0.00718 | 0.01162 | 0.01141 | 0.00493 | 0.00716 | 0.00345 |
| Capital Goods | 0.00146 | 0.00098 | 0.03606 | 0.05987 | 0.06887 | 0.00423 | 0.01243 | 0.14964 | 0.01324 | 0 | 0 | 0.00241 | 0.00447 | 0.01141 | 0.01098 | 0.00279 | 0.00513 | 0.00242 |
| Coal (Coal Steam and Coke) | 0 | 0 | 0 | 0 | 0 | 0.00006 | 0.00649 | 0.00271 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bagasse | 0 | 0 | 0 | 0 | 0 | 0 | 0.00599 | 0 | 0 | 0.43077 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kerosene | 0 | 0 | 0 | 0 | 0 | 0.00002 | 0 | 0.00006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oil (diesel, fuel, naphtha) | 0.0057 | 0.00116 | 0.016 | 0.00545 | 0 | 0.00077 | 0.00122 | 0.00146 | 0 | 0 | 0 | 0.02635 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gasoline | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Alcohol | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Alcohol | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gas (LPG,city gas, natural gas) | 0 | 0 | 0 | 0.00197 | 0 | 0.00005 | 0.00008 | 0.00015 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Electricity | 0.00356 | 0.00766 | 0.02509 | 0.00218 | 0.00437 | 0.0038 | 0.00384 | 0.00447 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01301 | 0 |
| Fuelwood | 0.00519 | 0.01375 | 0.00163 | 0 | 0 | 0.0016 | 0.00176 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Veg. Charcoal | 0 | 0 | 0.00096 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Civil Construction | 0 | 0.00009 | 0.00264 | 0.00613 | 0.00093 | 0.00095 | 0.00111 | 0.00193 | 0.00289 | 0 | 0 | 0 | 0 | 0.00972 | 0.00947 | 0 | 0.00087 | 0 |
| Financial/Commercial Services | 0.00806 | 0.00259 | 0.05855 | 0.09067 | 0.02149 | 0.01901 | 0.02265 | 0.02777 | 0.01566 | 0.01906 | 0.02257 | 0.00597 | 0.01325 | 0.02134 | 0.02066 | 0.00911 | 0.0165 | 0.00639 |
| Commerce | 0.0008 | 0.00122 | 0.01462 | 0.00805 | 0.01011 | 0.00909 | 0.00683 | 0.01449 | 0.00687 | 0.00956 | 0.00424 | 0.00216 | 0.00407 | 0.00655 | 0.00646 | 0.00279 | 0.00406 | 0.00195 |
| Transportation/Communication | 0.00334 | 0.00504 | 0.01293 | 0.0082 | 0.00554 | 0.00504 | 0.00474 | 0.00603 | 0.0236 | 0.02101 | 0.02885 | 0.00855 | 0.01079 | 0.01754 | 0.01701 | 0.01222 | 0.00843 | 0.00561 |
| Public Services | 0.00023 | 0.00055 | 0.00326 | 0.00254 | 0.00068 | 0.00066 | 0.00202 | 0.00138 | 0.00114 | 0.00101 | 0.00051 | 0.0006 | 0.00055 | 0.00085 | 0.00066 | 0.00054 | 0.00045 | 0.00026 |
| Private Services | 0.00374 | 0.00564 | 0.02696 | 0.0252 | 0.00913 | 0.00803 | 0.0076 | 0.01236 | 0.00585 | 0.00519 | 0.00288 | 0.0018 | 0.00266 | 0.00423 | 0.00431 | 0.00182 | 0.00264 | 0.00129 |
| Carbon Dioxide Pollution | 0.33687 | 0 | 0 | 0 | 0.58481 | 0.47082 | 0.37403 | 0.21056 | 0.57613 | 0 | 0.57611 | 0.57613 | 0.57613 | 0 | 0 | 0.57613 | 0.6025 | 0.62477 |
| Government | 0.0176 | 0.01958 | 0.03663 | 0.02966 | 0.00581 | 0.00763 | 0.00667 | 0.00932 | 0.01143 | 0.0062 | 0.00543 | 0.00247 | 0.00517 | 0.00645 | 0.00618 | 0.00391 | 0.00518 | 0.00153 |
| Indirect Taxes | 0.00603 | 0.00975 | 0.03796 | 0.02327 | 0.01543 | 0 | 0.02571 | 0.03576 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subsidies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ROW-Current | 0.00017 | 0.00028 | 0.00142 | 0.0043 | 0.00449 | 0.0059 | 0.00956 | 0.01043 | 0.00934 | 0.02694 | 0.16274 | 0.27179 | 0.00723 | 0.01205 | 0.01206 | 0.12529 | 0.04509 | 0.00371 |
| ROW-Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Social Accounting Matrix SAM-TECH, Brazil, 1985, Marginal Expenditures Propensities Matrix



| | Veg Char | Other | Construct | Financial | Commerc | Transport | Public | Private | CO2 | Gov't | Ind Taxes | Subsidies | Capital | ROW-Cur | ROW-Cap |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | E110.11 | E110.12 | A111 | A112 | A113 | A114 | A115 | A116 | CO2 | G | T | S | DKF | ROW-C | ROW-K |
| Unskilled Ag Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Ag Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof. Ag Labor | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ag Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unskilled Non Ag Labor | 0.01458 | 0 | 0.02806 | 0.02926 | 0.04516 | 0.01515 | 0.22752 | 0.09463 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Skilled Non-Ag Labor | 0.00996 | 0 | 0.07219 | 0.03603 | 0.07295 | 0.01814 | 0.1881 | 0.09802 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mgrs/Prof Non-Ag Labor | 0.00176 | 0 | 0.01847 | 0.01569 | 0.02047 | 0.00576 | 0.08266 | 0.03166 | 0 | 0 | 0 | 0 | 0 | 0.00021 | 0 |
| Non-Ag Capital | 0.00797 | 0.01423 | 0.20999 | 0.33319 | 0.38716 | 0.06797 | 0.05847 | 0.22603 | 0 | 0 | 0 | 0 | 0 | 0.08955 | 0 |
| Rural Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00537 | 0 | 0 | 0 | 0 | 0.00007 | 0 |
| Rural Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00351 | 0.00579 | 0 | 0 | 0 | 0 | 0 |
| Rural Workers/Tenant Farmers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00103 | 0.01212 | 0 | 0 | 0 | 0 | 0 |
| Rural Mgrs /Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00093 | 0.02693 | 0 | 0 | 0 | 0.00053 | 0 |
| Urban Capitalists | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02448 | 0 | 0 | 0 | 0 | 0.00018 | 0 |
| Urban Mgrs /Prof. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01128 | 0.0778 | 0 | 0 | 0 | 0.00095 | 0 |
| Urban Sm. Producers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02341 | 0.1362 | 0 | 0 | 0 | 0 | 0 |
| Urban Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01549 | 0.04854 | 0 | 0 | 0 | 0 | 0 |
| Urban Non-Organized Workers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01454 | 0.0257 | 0 | 0 | 0 | 0 | 0 |
| Export Agriculture | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00149 | 0.04871 | 0 | 0 | 0.00566 | 0.00028 | 0.00924 | 0 |
| Traditional Agriculture | 0.02956 | 0 | 0 | 0 | 0 | 0.00005 | 0.01022 | 0.01076 | 0.02629 | 0 | 0 | 0.0265 | 0.02412 | 0.01724 | 0 |
| Livestock | 0 | 0 | 0 | 0 | 0 | 0 | 0.00011 | 0.0014 | 0 | 0 | 0 | 0.01152 | 0.02904 | 0.00075 | 0 |
| Mineral Extraction | 0 | 0 | 0.01103 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0019 | 0.06672 | 0 |
| Non-Mineral Extraction | 0.08669 | 0.19266 | 0 | 0 | 0 | 0 | 0.00116 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00017 | 0 |
| Durable Consumer Goods | 0 | 0 | 0.03458 | 0.00022 | 0.00105 | 0.00169 | 0.0016 | 0.01094 | 0.06553 | 0 | 0 | 0.03694 | 0.04009 | 0.06817 | 0 |
| Non-Durable Consumer Goods | 0.00448 | 0.2012 | 0.00171 | 0.00225 | 0.00037 | 0.00087 | 0.01609 | 0.15467 | 0.14662 | 0 | 0 | 0.23248 | 0.00275 | 0.25763 | 0 |
| Intermediate Goods | 0.00309 | 0.13802 | 0.33616 | 0.01408 | 0.03004 | 0.01029 | 0.02478 | 0.08378 | 0.14936 | 0 | 0 | 0.02336 | 0.00749 | 0.15521 | 0 |
| Capital Goods | 0 | 0.05692 | 0.04747 | 0.00072 | 0.00283 | 0.01405 | 0.01811 | 0.06631 | 0.01829 | 0 | 0 | 0.04718 | 0.06812 | 0.08469 | 0 |
| Coal (Coal Steam and Coke) | 0 | 0 | 0 | 0 | 0 | 0.00007 | 0 | 0 | 0.00395 | 0 | 0 | 0 | 0.00017 | 0 | 0 |
| Bagasse | 0 | 0 | 0 | 0 | 0 | 0.00225 | 0 | 0 | 0 | 0 | 0 | 0.04268 | 0.00007 | 0 | 0 |
| Kerosene | 0 | 0 | 0.00001 | 0 | 0.00072 | 0.00163 | 0.0002 | 0 | 0.00156 | 0 | 0 | 0.00004 | 0.00029 | 0.00274 | 0 |
| Oil (diesel, fuel, naphtha) | 0 | 0 | 0.0068 | 0 | 0.01388 | 0.01749 | 0.00152 | 0 | 0.01931 | 0 | 0 | 0.00582 | 0.00374 | 0.01216 | 0 |
| Gasoline | 0 | 0 | 0 | 0 | 0 | 0.00222 | 0 | 0 | 0.00529 | 0 | 0 | 0.00601 | 0.00145 | 0.01294 | 0 |
| Alcohol | 0 | 0 | 0 | 0 | 0 | 0.00115 | 0 | 0 | 0 | 0 | 0 | 0.06879 | 0.00011 | 0.00054 | 0 |
| Alcohol | 0 | 0 | 0 | 0 | 0 | 0.0012 | 0 | 0 | 0 | 0 | 0 | 0.06604 | 0.00011 | 0.00057 | 0 |
| Gas (LPG,city gas, natural gas) | 0 | 0 | 0.0001 | 0 | 0.0208 | 0 | 0.00023 | 0.00004 | 0.00495 | 0 | 0 | 0 | 0.00026 | 0.00016 | 0 |
| Electricity | 0 | 0 | 0.00932 | 0.00063 | 0.05074 | 0.0084 | 0.02465 | 0.00592 | 0.03493 | 0 | 0 | 0 | 0.00153 | 0.00008 | 0 |
| Fuelwood | 0 | 0 | 0.00182 | 0 | 0.00991 | 0.00024 | 0 | 0 | 0.02356 | 0 | 0 | 0 | 0.00011 | 0 | 0 |
| Veg. Charcoal | 0 | 0 | 0 | 0 | 0.02473 | 0 | 0 | 0 | 0.01144 | 0 | 0 | 0.00202 | 0.00005 | 0.00001 | 0 |
| Other | 0 | 0 | 0 | 0 | 0.00521 | 0.00246 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00008 | 0.00066 | 0 |
| Civil Construction | 0 | 0 | 0.0489 | 0.02457 | 0.00262 | 0.00212 | 0.00703 | 0.00482 | 0 | 0 | 0 | 0.00066 | 0.48229 | 0.0106 | 0 |
| Financial/Commercial Services | 0.00661 | 0.12436 | 0.02473 | 0.43689 | 0.05915 | 0.00903 | 0.15837 | 0.04406 | 0.005 | 0 | 0 | 0.04551 | 0.03289 | 0.02148 | 0 |
| Commerce | 0.00173 | 0.03785 | 0.00181 | 0 | 0.01166 | 0 | 0.00319 | 0 | 0 | 0 | 0 | 0.25704 | 0.02294 | 0.08805 | 0 |
| Transportation/Communication | 0.00528 | 0.07484 | 0.00223 | 0.00571 | 0.03765 | 0.01378 | 0.01596 | 0.00439 | 0.33 | 0 | 0 | 0.10902 | 0.00128 | 0.08979 | 0 |
| Public Services | 0.00023 | 0.00171 | 0.00024 | 0.00044 | 0.00185 | 0.00023 | 0.02172 | 0.00249 | 0.005 | 0.66691 | 0 | 0.0005 | 0 | 0 | 0 |
| Private Services | 0.00113 | 0.0222 | 0.01529 | 0.01458 | 0.01901 | 0.01353 | 0.05278 | 0.0325 | 0 | 0 | 0 | 0.01222 | 0 | 0.00017 | 0 |
| Carbon Dioxide Pollution | 0.82477 | 0 | 0 | 0.01808 | 0 | 0.75433 | 0.0354 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Government | 0.00186 | 0.07057 | 0.01542 | 0.02447 | 0.02843 | 0.00499 | 0.00429 | 0.0166 | 0 | 0 | 0.8501 | 0 | 0.26543 | 0 | 0 |
| Indirect Taxes | 0 | 0 | 0.1126 | 0.03963 | 0.15169 | 0.02721 | 0.04293 | 0.10724 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subsidies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1499 | 0 | 0 | 0 | 0 |
| Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| ROW-Current | 0.0003 | 0.06545 | 0.00308 | 0.00354 | 0.00172 | 0.00572 | 0.00091 | 0.00224 | 0 | 0 | 0 | 0 | 0.01156 | 0 | 0 |
| ROW-Capital | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00185 | 0.00878 | 0 |

Appendix 6 Social Accounting Matrix SAM-TECH, Brazil, 1985, Fixed Price Multiplier Matrix



| | | A-unskill F1 | A-skilled F2 | A-mgrs F3 | A-capital F4 | U-unskill F5 | U-skill F6 | U-mgrs F7 | U-capital F8 |
|---|---|---|---|---|---|---|---|---|---|
| Unskilled Ag. Labor | F1 | 1.005676 | 0.0053395 | 0.0030992 | 0.0031094 | 0.0053168 | 0.0051945 | 0.0031497 | 0.003085 |
| Skilled Ag. Labor | F2 | 0.0189231 | 1.017792 | 0.0103342 | 0.0103758 | 0.0177729 | 0.0173495 | 0.0105231 | 0.0103095 |
| Mgrs/Prof. Ag Labor | F3 | 0.0010399 | 0.0009773 | 1.000573 | 0.0005797 | 0.0009893 | 0.0009631 | 0.0005911 | 0.0005786 |
| Ag Capital | F4 | 0.1243573 | 0.1171602 | 0.0688745 | 1.069694 | 0.1177241 | 0.1148811 | 0.0708578 | 0.0692662 |
| Unskilled Non Ag. Labor | F5 | 0.1479942 | 0.1444501 | 0.0967202 | 0.095452 | 1.145482 | 0.1448476 | 0.0998261 | 0.0965408 |
| Skilled Non-Ag. Labor | F6 | 0.1695924 | 0.164381 | 0.1083042 | 0.1071556 | 0.1681914 | 1.166797 | 0.1123093 | 0.1092381 |
| Mgrs/Prof. Non-Ag Labor | F7 | 0.0649487 | 0.063052 | 0.0415368 | 0.0410515 | 0.0637442 | 0.06327 | 1.042804 | 0.0414774 |
| Non-Ag. Capital | F8 | 0.7952837 | 0.7598678 | 0.4787493 | 0.4715801 | 0.7844721 | 0.7718768 | 0.4914866 | 1.48124 |
| Rural Capitalists | HH1 | 0.0820205 | 0.0774583 | 0.0458365 | 0.5948149 | 0.077743 | 0.0759634 | 0.0473374 | 0.0461969 |
| Rural Sm. Producers | HH2 | 0.3085651 | 0.5150104 | 0.0297228 | 0.3037793 | 0.0504648 | 0.0493144 | 0.0306367 | 0.0299102 |
| Rural Workers/Tenant Farmers | HH3 | 0.6811538 | 0.4835745 | 0.0084592 | 0.0085424 | 0.0144076 | 0.0140852 | 0.0086607 | 0.0084661 |
| Rural Mgrs /Prof. | HH4 | 0.0141606 | 0.0795613 | 1.007902 | 0.0841427 | 0.0134177 | 0.0131087 | 0.0081545 | 0.0079603 |
| Urban Capitalists | HH5 | 0.3903116 | 0.3729298 | 0.233794 | 0.2321961 | 0.3829435 | 0.376754 | 0.2409185 | 0.646993 |
| Urban Mgrs./Prof. | HH6 | 0.1561051 | 0.1501451 | 0.0958645 | 0.0954413 | 0.1527134 | 0.1507898 | 1.095118 | 0.17475 |
| Urban Sm Producers | HH7 | 0.359239 | 0.3439221 | 0.2169079 | 0.2155818 | 0.4377232 | 0.5272905 | 0.2237921 | 0.5400764 |
| Urban Organized Workers | HH8 | 0.1989702 | 0.19244 | 0.1250466 | 0.1246821 | 0.5816491 | 0.6860507 | 0.1297057 | 0.1489237 |
| Urban Non-Organized Workers | HH9 | 0.2627932 | 0.1780585 | 0.1160364 | 0.1156846 | 0.7085045 | 0.5057636 | 0.1203077 | 0.1321127 |
| Export Agriculture | A101 | 0.1667075 | 0.158706 | 0.0957434 | 0.0982462 | 0.1576639 | 0.1548384 | 0.0995153 | 0.0965504 |
| Traditional Agriculture | A102 | 0.1687233 | 0.1585341 | 0.0932692 | 0.0945306 | 0.1611554 | 0.1567497 | 0.0965323 | 0.0944839 |
| Livestock | A103 | 0.0553807 | 0.0519585 | 0.0295913 | 0.0293122 | 0.0511958 | 0.0500641 | 0.0295563 | 0.0290497 |
| Mineral Extraction | A104 | 0.0178462 | 0.017049 | 0.0104605 | 0.0106 | 0.0169341 | 0.0166709 | 0.0108029 | 0.0104782 |
| Non-Mineral Extraction | A105 | 0.0495111 | 0.0468558 | 0.0283441 | 0.0294551 | 0.0480718 | 0.0471283 | 0.0304689 | 0.0296651 |
| Durable Consumer Goods | A106 | 0.2291998 | 0.225181 | 0.159179 | 0.1628563 | 0.2223511 | 0.2218656 | 0.1665643 | 0.1575199 |
| Non-Durable Consumer Goods | A107 | 0.9151875 | 0.8587896 | 0.4879957 | 0.4820042 | 0.8376659 | 0.8188072 | 0.4849368 | 0.4750896 |
| Intermediate Goods | A108 | 0.8403788 | 0.8060702 | 0.5019775 | 0.512171 | 0.8036197 | 0.7924109 | 0.5230451 | 0.5064054 |
| Capital Goods | A109 | 0.146489 | 0.1432151 | 0.0955915 | 0.0964873 | 0.1413183 | 0.140825 | 0.0996366 | 0.0955825 |
| Coal (Coal Steam and Coke) | E110-1 | 0.0161734 | 0.0154809 | 0.0095359 | 0.0098225 | 0.0154393 | 0.0152001 | 0.009988 | 0.0096699 |
| Bagasse | E110-2 | 0.0135689 | 0.0129868 | 0.0080023 | 0.0081115 | 0.0128906 | 0.0126972 | 0.0082569 | 0.0079954 |
| Kerosene | E110-3 | 0.0073885 | 0.0067543 | 0.0036036 | 0.0037037 | 0.0059842 | 0.0058743 | 0.0037633 | 0.0036627 |
| Oil (diesel, fuel, naphtha) | E110-4 | 0.0807022 | 0.076758 | 0.0465079 | 0.0478342 | 0.0778921 | 0.0763958 | 0.0487562 | 0.0475298 |
| Gasoline | E110-5 | 0.0168814 | 0.0161611 | 0.0100631 | 0.010192 | 0.0160903 | 0.0158657 | 0.0109069 | 0.0104418 |
| Ethanol-M | E110-6 | 0.001708 | 0.0016382 | 0.0011268 | 0.001053 | 0.0016267 | 0.0016109 | 0.0014051 | 0.0012844 |
| Ethanol-T | E110-7 | 0.0017558 | 0.0016831 | 0.0011459 | 0.0010785 | 0.0016707 | 0.0016537 | 0.0014165 | 0.0012988 |
| Gas (LPG,city gas, natural gas) | E110-8 | 0.0203622 | 0.0187292 | 0.0107143 | 0.0112041 | 0.0200517 | 0.0195001 | 0.0121164 | 0.012025 |
| Electricity | E110-9 | 0.130184 | 0.1235793 | 0.0752662 | 0.0791497 | 0.1288238 | 0.1263014 | 0.0818403 | 0.0794762 |
| Fuelwood | E110-10 | 0.0727306 | 0.0685572 | 0.0410357 | 0.0416483 | 0.0667632 | 0.0655215 | 0.0422235 | 0.041183 |
| Veg. Charcoal | E110-11 | 0.0379279 | 0.0353017 | 0.0204234 | 0.0214073 | 0.0366955 | 0.0357647 | 0.0221737 | 0.0220037 |
| Other | E110-12 | 0.004313 | 0.0040115 | 0.0023567 | 0.0024302 | 0.004538 | 0.0043956 | 0.00256 | 0.0025894 |
| Civil Construction | A111 | 0.0273369 | 0.026256 | 0.0165574 | 0.015625 | 0.0256268 | 0.0253135 | 0.0160473 | 0.0154677 |
| Financial/Commercial Services | A112 | 0.7379374 | 0.7050633 | 0.4352702 | 0.3991363 | 0.6736764 | 0.6636958 | 0.4061522 | 0.3901735 |
| Commerce | A113 | 0.2646032 | 0.2330797 | 0.1281629 | 0.1420392 | 0.3425115 | 0.3241683 | 0.1632623 | 0.1791894 |
| Transportation/Communication | A114 | 1.195181 | 1.139279 | 0.6879292 | 0.6884124 | 1.121458 | 1.102369 | 0.6962394 | 0.6743982 |
| Public Services | A115 | 0.0316127 | 0.0317749 | 0.0220737 | 0.0207417 | 0.0301529 | 0.0304736 | 0.0210774 | 0.0199786 |
| Private Services | A116 | 0.3267935 | 0.3495184 | 0.2973343 | 0.2873977 | 0.3295284 | 0.3450981 | 0.3110677 | 0.292135 |
| Carbon Dioxide Pollution | CO2 | 2.577523 | 2.462727 | 1.503878 | 1.55917 | 2.458181 | 2.417034 | 1.580863 | 1.53099 |

| | | R-capitalist HH1 | R-sm prod HH2 | R-workers HH3 | R-mgrs HH4 | U-capital HH5 | U-mgrs HH6 | U-sm prod HH7 |
|---|---|---|---|---|---|---|---|---|
| Unskilled Ag. Labor | F1 | 0.0027115 | 0.0050689 | 0.0059237 | 0.0030992 | 0.0027222 | 0.0031619 | 0.0047045 |
| Skilled Ag. Labor | F2 | 0.0090662 | 0.0168804 | 0.019748 | 0.0103342 | 0.0091095 | 0.0105641 | 0.0157075 |
| Mgrs/Prof. Ag Labor | F3 | 0.0005143 | 0.0009288 | 0.0010824 | 0.0005733 | 0.0005183 | 0.0005934 | 0.0008739 |
| Ag Capital | F4 | 0.0617849 | 0.1117593 | 0.1293224 | 0.0688745 | 0.062123 | 0.0711335 | 0.1045377 |
| Unskilled Non Ag. Labor | F5 | 0.0871158 | 0.1473971 | 0.1482657 | 0.0967202 | 0.0871066 | 0.1002145 | 0.1470359 |
| Skilled Non-Ag. Labor | F6 | 0.0975591 | 0.1660234 | 0.1706664 | 0.1083042 | 0.0974961 | 0.1127462 | 0.1675045 |
| Mgrs/Prof. Non-Ag Labor | F7 | 0.0373004 | 0.063741 | 0.0654053 | 0.0415368 | 0.0372961 | 0.0429703 | 0.0632061 |
| Non-Ag. Capital | F8 | 0.4204453 | 0.7478988 | 0.8113872 | 0.4787493 | 0.4205937 | 0.4933985 | 0.7449172 |
| Rural Capitalists | HH1 | 1.041551 | 0.0742437 | 0.0851038 | 0.0458365 | 0.0417407 | 0.0475215 | 0.0693951 |
| Rural Sm. Producers | HH2 | 0.026834 | 1.048205 | 0.0553667 | 0.0297228 | 0.0269521 | 0.0307559 | 0.0450089 |
| Rural Workers/Tenant Farmers | HH3 | 0.0075299 | 0.0137799 | 1.01593 | 0.0084592 | 0.0075581 | 0.0086944 | 0.0128166 |
| Rural Mgrs /Prof. | HH4 | 0.0071498 | 0.0128043 | 0.0146983 | 1.007902 | 0.0071831 | 0.0081863 | 0.0119677 |
| Urban Capitalists | HH5 | 0.2079855 | 0.3668495 | 0.3985836 | 0.233794 | 1.208066 | 0.2418557 | 0.3615718 |
| Urban Mgrs./Prof. | HH6 | 0.086235 | 0.1493608 | 0.1585806 | 0.0958645 | 0.0862512 | 1.099378 | 0.1467292 |
| Urban Sm Producers | HH7 | 0.1936671 | 0.3395148 | 0.3662086 | 0.2169079 | 0.1937209 | 0.2246626 | 1.334915 |
| Urban Organized Workers | HH8 | 0.1135497 | 0.1933813 | 0.2010166 | 0.1250466 | 0.1135306 | 0.1302103 | 0.1913376 |
| Urban Non-Organized Workers | HH9 | 0.1054365 | 0.1792602 | 0.1856191 | 0.1160364 | 0.1054255 | 0.1207757 | 0.1770714 |
| Export Agriculture | A101 | 0.0888765 | 0.1543531 | 0.1719012 | 0.0957434 | 0.0889428 | 0.0999025 | 0.1432346 |
| Traditional Agriculture | A102 | 0.0842497 | 0.1507325 | 0.1754699 | 0.0932692 | 0.0849685 | 0.0969078 | 0.1423201 |
| Livestock | A103 | 0.0249377 | 0.0489302 | 0.0581139 | 0.0295913 | 0.0249954 | 0.0296713 | 0.044992 |
| Mineral Extraction | A104 | 0.009556 | 0.0166836 | 0.0183405 | 0.0104605 | 0.0095629 | 0.0108449 | 0.0156817 |
| Non-Mineral Extraction | A105 | 0.0272251 | 0.0452164 | 0.0510916 | 0.0283441 | 0.0269951 | 0.0305874 | 0.0445392 |
| Durable Consumer Goods | A106 | 0.1600939 | 0.2301447 | 0.2295771 | 0.159179 | 0.1593564 | 0.1672122 | 0.2185106 |
| Non-Durable Consumer Goods | A107 | 0.4082711 | 0.807817 | 0.9615937 | 0.4879957 | 0.4091645 | 0.4868233 | 0.7349169 |
| Intermediate Goods | A108 | 0.4674259 | 0.7956538 | 0.8592933 | 0.5019775 | 0.4675546 | 0.5250797 | 0.7525632 |
| Capital Goods | A109 | 0.0898149 | 0.1460867 | 0.1470903 | 0.0955915 | 0.0897183 | 0.1000242 | 0.1411941 |
| Coal (Coal Steam and Coke) | E110-1 | 0.008992 | 0.0152292 | 0.0165691 | 0.0095359 | 0.0089958 | 0.0100269 | 0.0142708 |
| Bagasse | E110-2 | 0.0073178 | 0.0127569 | 0.0139178 | 0.0080023 | 0.0073246 | 0.008289 | 0.0119298 |
| Kerosene | E110-3 | 0.0033566 | 0.005808 | 0.0081361 | 0.0036036 | 0.0033593 | 0.0037779 | 0.0054562 |
| Oil (diesel, fuel, naphtha) | E110-4 | 0.0434548 | 0.074816 | 0.0829496 | 0.0465079 | 0.0434817 | 0.0489458 | 0.0709425 |
| Gasoline | E110-5 | 0.0092724 | 0.0158713 | 0.0173086 | 0.0100631 | 0.0099556 | 0.0109493 | 0.0151437 |
| Ethanol-M | E110-6 | 0.0009709 | 0.0015897 | 0.0017584 | 0.0011268 | 0.0014555 | 0.0014106 | 0.0015943 |
| Ethanol-T | E110-7 | 0.0009928 | 0.0016338 | 0.0018078 | 0.0011459 | 0.0014565 | 0.001422 | 0.0016298 |
| Gas (LPG,city gas, natural gas) | E110-8 | 0.0104312 | 0.0170669 | 0.0215064 | 0.0107143 | 0.0104493 | 0.0121635 | 0.0187021 |
| Electricity | E110-9 | 0.0737591 | 0.1205469 | 0.1333996 | 0.0752662 | 0.0719985 | 0.0821586 | 0.1196933 |
| Fuelwood | E110-10 | 0.0379512 | 0.0647574 | 0.076204 | 0.0410357 | 0.0379155 | 0.0423878 | 0.0612601 |
| Veg. Charcoal | E110-11 | 0.0197794 | 0.0329257 | 0.0397543 | 0.0204234 | 0.019758 | 0.0222599 | 0.0333708 |
| Other | E110-12 | 0.0022017 | 0.0038148 | 0.0044399 | 0.0023567 | 0.0021986 | 0.00257 | 0.0040777 |
| Civil Construction | A111 | 0.0133131 | 0.0258245 | 0.0280519 | 0.0165574 | 0.0133687 | 0.0161097 | 0.0240013 |
| Financial/Commercial Services | A112 | 0.3263621 | 0.6837401 | 0.7642499 | 0.4352702 | 0.3284341 | 0.4077322 | 0.6125787 |
| Commerce | A113 | 0.1366541 | 0.2096572 | 0.2710823 | 0.1281629 | 0.1354248 | 0.1638974 | 0.3046453 |
| Transportation/Communication | A114 | 0.6067678 | 1.10885 | 1.2331 | 0.6879292 | 0.6081233 | 0.6989478 | 1.014347 |
| Public Services | A115 | 0.0178288 | 0.0339425 | 0.0309967 | 0.0220737 | 0.0179243 | 0.0211594 | 0.0303833 |
| Private Services | A116 | 0.2785363 | 0.4095617 | 0.2974099 | 0.2973343 | 0.2775627 | 0.3122778 | 0.4382784 |
| Carbon Dioxide Pollution | CO2 | 1.429644 | 2.415506 | 2.644787 | 1.503878 | 1.430425 | 1.587012 | 2.249894 |

Social Accounting Matrix SAM-TECH, Brazil, 1985, Fixed Price Multiplier Matrix

| | U-org lab HH8 | U-unorg la HH9 | Ag-Export A101 | Ag-Trad A102 | Livestock A103 | Minerals A104 | Non-min A105 | Cons-Dur A106 | Con-ND A107 | Intermed. A108 | Capital A109 | Coal E110-1 | Bagasse E110-2 | Kerosene E110-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unskilled Ag. Labor | 0.0051419 | 0.0055434 | 0.0116713 | 0.0158346 | 0.0621612 | 0.0035105 | 0.0038015 | 0.0058444 | 0.0099974 | 0.0055112 | 0.0048776 | 0.0056226 | 0.0109548 | 0.0051115 |
| Skilled Ag. Labor | 0.0171397 | 0.0185692 | 0.0330521 | 0.0661091 | 0.1862615 | 0.0117654 | 0.0127249 | 0.0195267 | 0.0327945 | 0.0187026 | 0.0163876 | 0.0188159 | 0.0446308 | 0.0171094 |
| Mgrs/Prof. Ag Labor | 0.0009439 | 0.0010412 | 0.0013653 | 0.0064899 | 0.0033894 | 0.0006701 | 0.0007187 | 0.0011327 | 0.0016172 | 0.0011323 | 0.0009542 | 0.0010857 | 0.0041956 | 0.0009904 |
| Ag Capital | 0.1131302 | 0.1232112 | 0.3139131 | 0.5552086 | 0.5985116 | 0.0798132 | 0.0856974 | 0.1381392 | 0.1977135 | 0.1322346 | 0.1138044 | 0.1311232 | 0.3674997 | 0.1196967 |
| Unskilled Non Ag. Labor | 0.1421965 | 0.1476353 | 0.1514041 | 0.1290406 | 0.1224713 | 0.13631 | 0.1837652 | 0.1797063 | 0.1671078 | 0.1798119 | 0.2153429 | 0.1729743 | 0.1582274 | 0.1798322 |
| Skilled Non-Ag. Labor | 0.1630346 | 0.172074 | 0.1682285 | 0.143499 | 0.1357943 | 0.1997495 | 0.3274262 | 0.2006225 | 0.1935655 | 0.1835208 | 0.2219954 | 0.1966023 | 0.1718293 | 0.1948125 |
| Mgrs/Prof. Non-Ag Labor | 0.0621434 | 0.0650018 | 0.0670403 | 0.0568651 | 0.0540161 | 0.0610135 | 0.080431 | 0.0815716 | 0.0727514 | 0.0838123 | 0.1022912 | 0.0754468 | 0.0605318 | 0.0665556 |
| Non-Ag. Capital | 0.7546407 | 0.8126714 | 0.7548529 | 0.646678 | 0.6194956 | 1.125531 | 1.058313 | 0.8667274 | 0.8679044 | 0.8877757 | 0.8790237 | 0.9315791 | 0.7718322 | 0.730626 |
| Rural Capitalists | 0.0749144 | 0.0811584 | 0.1917281 | 0.3187864 | 0.3394061 | 0.0533216 | 0.0570867 | 0.0942478 | 0.1261506 | 0.0889349 | 0.0769343 | 0.0894993 | 0.2138451 | 0.0818953 |
| Rural Sm. Producers | 0.0486662 | 0.0526605 | 0.1170725 | 0.1960978 | 0.2735602 | 0.0344594 | 0.0369423 | 0.0604761 | 0.083506 | 0.0570344 | 0.0495133 | 0.0575793 | 0.1321815 | 0.052653 |
| Rural Workers/Tenant Farmers | 0.0139347 | 0.0150101 | 0.0270382 | 0.0443171 | 0.1309337 | 0.0096896 | 0.0104369 | 0.0165994 | 0.025444 | 0.0155933 | 0.013722 | 0.0159455 | 0.0306021 | 0.014548 |
| Rural Mgrs /Prof. | 0.0129269 | 0.0140106 | 0.030854 | 0.0556265 | 0.063234 | 0.0091839 | 0.0098376 | 0.016153 | 0.0219189 | 0.0152883 | 0.0132251 | 0.0153684 | 0.0372697 | 0.0140579 |
| Urban Capitalists | 0.3692558 | 0.3964022 | 0.4000273 | 0.3317063 | 0.3063104 | 0.5067281 | 0.4815228 | 0.4409855 | 0.4380194 | 0.4401938 | 0.4279557 | 0.4635646 | 0.3739492 | 0.3747696 |
| Urban Mgrs /Prof. | 0.1481287 | 0.1570319 | 0.1671492 | 0.1375685 | 0.1260565 | 0.1691215 | 0.1843214 | 0.1880618 | 0.1777796 | 0.1875929 | 0.2013378 | 0.1851567 | 0.1467759 | 0.1577279 |
| Urban Sm. Producers | 0.3403491 | 0.364228 | 0.3715032 | 0.3075736 | 0.2832853 | 0.4512289 | 0.4590028 | 0.4108649 | 0.4055966 | 0.4055155 | 0.404393 | 0.4264907 | 0.346549 | 0.3562918 |
| Urban Organized Workers | 1.189821 | 0.1997801 | 0.2153743 | 0.1769837 | 0.1610248 | 0.2045736 | 0.2858265 | 0.2416293 | 0.2311258 | 0.227742 | 0.2547583 | 0.2359378 | 0.1992368 | 0.229219 |
| Urban Non-Organized Workers | 0.1754256 | 1.184126 | 0.2007478 | 0.1653491 | 0.1541469 | 0.1809168 | 0.2482097 | 0.2245477 | 0.2138772 | 0.2136873 | 0.2397296 | 0.218217 | 0.1860817 | 0.2144865 |
| Export Agriculture | 0.1537641 | 0.1628436 | 1.219474 | 0.1658185 | 0.1351487 | 0.111413 | 0.1185901 | 0.2177079 | 0.2415527 | 0.1861275 | 0.1651902 | 0.1976035 | 0.1429373 | 0.1817137 |
| Traditional Agriculture | 0.1532329 | 0.1699881 | 0.1958717 | 1.200647 | 0.2026248 | 0.1098978 | 0.1175922 | 0.1867012 | 0.2530057 | 0.1890028 | 0.1575075 | 0.1787199 | 0.7708207 | 0.1631716 |
| Livestock | 0.0498469 | 0.0531832 | 0.0562706 | 0.0556088 | 1.056224 | 0.0324921 | 0.0356305 | 0.0503506 | 0.110274 | 0.0470557 | 0.0433074 | 0.0497315 | 0.0462228 | 0.0448914 |
| Mineral Extraction | 0.0165248 | 0.0174355 | 0.0221667 | 0.0208608 | 0.0225785 | 1.081636 | 0.0157184 | 0.0235674 | 0.0260353 | 0.0410997 | 0.025025 | 0.0242703 | 0.0173412 | 0.0182623 |
| Non-Mineral Extraction | 0.0461233 | 0.0500668 | 0.0643832 | 0.0497247 | 0.0433817 | 0.0407132 | 1.038404 | 0.0623951 | 0.0604054 | 0.0607222 | 0.0522628 | 0.1555978 | 0.0729472 | 0.0533033 |
| Durable Consumer Goods | 0.2223649 | 0.2229604 | 0.3068776 | 0.2386256 | 0.1998344 | 0.1738437 | 0.1809547 | 1.360566 | 0.283011 | 0.264361 | 0.2484209 | 0.2833162 | 0.2088628 | 0.2545297 |
| Non-Durable Consumer Goods | 0.814872 | 0.8709111 | 0.8553022 | 0.6919199 | 0.6287599 | 0.5304354 | 0.581947 | 0.823044 | 1.886606 | 0.7594937 | 0.7063181 | 0.8161189 | 0.6236416 | 0.7362449 |
| Intermediate Goods | 0.78504 | 0.8254446 | 1.114483 | 0.9067 | 0.8851048 | 0.690635 | 0.7161391 | 1.166393 | 1.1229 | 2.331623 | 1.200252 | 1.020131 | 0.7754249 | 0.9102226 |
| Capital Goods | 0.139434 | 0.1427165 | 0.1825981 | 0.1457687 | 0.1258072 | 0.154959 | 0.1856133 | 0.2629645 | 0.1767169 | 0.1800336 | 1.327186 | 0.1912793 | 0.1315834 | 0.1526135 |
| Coal (Coal Steam and Coke) | 0.0150827 | 0.0158886 | 0.0223167 | 0.016991 | 0.0144862 | 0.0120242 | 0.0126762 | 0.0220444 | 0.0210364 | 0.0278435 | 0.0221982 | 1.020235 | 0.0145943 | 0.0184194 |
| Bagasse | 0.01261 | 0.0132508 | 0.017313 | 0.0138265 | 0.0129124 | 0.0103388 | 0.0108124 | 0.0176028 | 0.0169634 | 0.0293288 | 0.0169787 | 0.0159079 | 1.768807 | 0.0143634 |
| Kerosene | 0.0058157 | 0.0061926 | 0.0082467 | 0.0061975 | 0.0051541 | 0.0042417 | 0.0045024 | 0.0078172 | 0.0075505 | 0.0069767 | 0.0063201 | 0.007482 | 0.0054362 | 1.006905 |
| Oil (diesel, fuel, naphtha) | 0.0754791 | 0.080778 | 0.1084196 | 0.0854283 | 0.0659565 | 0.0750185 | 0.0643255 | 0.1008867 | 0.098407 | 0.0921911 | 0.0830335 | 0.0969498 | 0.0737121 | 0.0887401 |
| Gasoline | 0.0156794 | 0.0165436 | 0.0230755 | 0.0171183 | 0.0136321 | 0.011845 | 0.012487 | 0.0218801 | 0.0210259 | 0.0195293 | 0.0174101 | 0.0209254 | 0.0149401 | 0.0192716 |
| Ethanol-M | 0.0015806 | 0.0016657 | 0.0019809 | 0.001561 | 0.0013429 | 0.0013087 | 0.001361 | 0.0019321 | 0.0018768 | 0.0017745 | 0.0016431 | 0.0019002 | 0.0014708 | 0.0017165 |
| Ethanol-T | 0.0016242 | 0.0017113 | 0.002039 | 0.0016041 | 0.0013779 | 0.001332 | 0.0013872 | 0.0019857 | 0.0019282 | 0.0018212 | 0.0016842 | 0.0019513 | 0.0015081 | 0.0017654 |
| Gas (LPG,city gas, natural gas) | 0.0185529 | 0.0213657 | 0.0229313 | 0.0176386 | 0.0149485 | 0.0136327 | 0.01653 | 0.0223407 | 0.0216036 | 0.0203306 | 0.0189214 | 0.0216102 | 0.0161994 | 0.0195339 |
| Electricity | 0.1234572 | 0.1342217 | 0.1701578 | 0.1313835 | 0.1129631 | 0.1189226 | 0.0998233 | 0.1663809 | 0.1603688 | 0.1504454 | 0.1375535 | 0.1544007 | 0.1153615 | 0.1411664 |
| Fuelwood | 0.064628 | 0.0692126 | 0.0971799 | 0.0759604 | 0.0711151 | 0.0495977 | 0.0506903 | 0.0897042 | 0.0892508 | 0.0823391 | 0.0717438 | 0.085339 | 0.0643374 | 0.0786052 |
| Veg. Charcoal | 0.0346926 | 0.0386968 | 0.046735 | 0.0351539 | 0.028792 | 0.0263816 | 0.0269766 | 0.0448407 | 0.0431417 | 0.0402391 | 0.0365109 | 0.0428359 | 0.0312833 | 0.0393259 |
| Other | 0.0042071 | 0.0048543 | 0.0044778 | 0.0035679 | 0.0031518 | 0.0029387 | 0.0031683 | 0.0044257 | 0.0042895 | 0.0040512 | 0.0038463 | 0.0043119 | 0.0034369 | 0.0039354 |
| Civil Construction | 0.0252073 | 0.0261958 | 0.0224094 | 0.020015 | 0.0197643 | 0.0228181 | 0.0291768 | 0.0244732 | 0.0239245 | 0.0237643 | 0.0245898 | 0.0263194 | 0.0205096 | 0.0202667 |
| Financial/Commercial Services | 0.667995 | 0.6914723 | 0.5185143 | 0.4862682 | 0.4962917 | 0.5254491 | 0.6229968 | 0.5543089 | 0.5460743 | 0.5379078 | 0.5470994 | 0.5429788 | 0.5191744 | 0.4867117 |
| Commerce | 0.289147 | 0.3876508 | 0.1938118 | 0.174096 | 0.1761034 | 0.1980184 | 0.217622 | 0.2143905 | 0.2099003 | 0.2066104 | 0.2200691 | 0.2110889 | 0.1944098 | 0.1850472 |
| Transportation/Communication | 1.099946 | 1.154468 | 1.412565 | 1.083785 | 0.9100129 | 0.7767153 | 0.8286128 | 1.347672 | 1.301714 | 1.211651 | 1.099615 | 1.308317 | 0.9873112 | 1.210232 |
| Public Services | 0.0313026 | 0.0292748 | 0.03355 | 0.0279929 | 0.0259127 | 0.0250912 | 0.0257777 | 0.0331189 | 0.0325892 | 0.0323501 | 0.0298128 | 0.0325287 | 0.0269786 | 0.028644 |
| Private Services | 0.3363263 | 0.3070151 | 0.2991738 | 0.2935641 | 0.2991438 | 0.300675 | 0.3128681 | 0.3031245 | 0.3050147 | 0.2938352 | 0.2972761 | 0.3021437 | 0.2886837 | 0.2570076 |
| Carbon Dioxide Pollution | 2.400458 | 2.533997 | 3.654975 | 2.681681 | 2.100707 | 1.780932 | 1.881326 | 3.447304 | 3.306233 | 3.060811 | 2.707705 | 3.279346 | 2.30311 | 3.029924 |

Social Accounting Matrix SAM-TECH, Brazil, 1985, Fixed Price Multiplier Matrix



| | Oil | Gasoline | Ethanol-M | Ethanol-T | Gas | Electricity | Fuelwood | Veg Char | Other | Construct | Financial | Commerce | Transport | Public | Private | CO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | E110-4 | E110-5 | E110-6 | E110-7 | E110-8 | E110-9 | E110-10 | E110-11 | E110-12 | A111 | A112 | A113 | A114 | A115 | A116 | CO2 |
| Unskilled Ag. Labor | 0.0045137 | 0.0055401 | 0.0119687 | 0.011501 | 0.0050935 | 0.0054894 | 0.0064741 | 0.0066894 | 0.0049329 | 0.0040342 | 0.0032998 | 0.0033482 | 0.0060633 | 0.0046165 | 0.0048735 | 0.0067951 |
| Skilled Ag. Labor | 0.015113 | 0.0185448 | 0.0488963 | 0.0466794 | 0.0170518 | 0.0183774 | 0.021861 | 0.0227873 | 0.0164196 | 0.0135874 | 0.0110401 | 0.0112178 | 0.0203461 | 0.0155686 | 0.0163267 | 0.0227588 |
| Mgrs/Prof. Ag Labor | 0.0008799 | 0.0010717 | 0.0046183 | 0.0043554 | 0.0009881 | 0.0010645 | 0.0013102 | 0.0014056 | 0.0008954 | 0.0007943 | 0.0006233 | 0.0006399 | 0.0011936 | 0.000901 | 0.0009095 | 0.0013316 |
| Ag Capital | 0.1065313 | 0.1293869 | 0.4032588 | 0.3827299 | 0.1194062 | 0.1285945 | 0.1554098 | 0.1633347 | 0.1074698 | 0.0939331 | 0.0744659 | 0.07639 | 0.1437189 | 0.1053061 | 0.1071739 | 0.1614186 |
| Unskilled Non Ag. Labor | 0.114832 | 0.1725339 | 0.1477256 | 0.2015786 | 0.1546648 | 0.1584465 | 0.1681718 | 0.1787039 | 0.1506446 | 0.1616583 | 0.1545445 | 0.1504947 | 0.1689772 | 0.3736923 | 0.2240051 | 0.1649578 |
| Skilled Non-Ag. Labor | 0.1303746 | 0.2201168 | 0.1670985 | 0.1960664 | 0.1875952 | 0.2025255 | 0.2011706 | 0.2033112 | 0.191405 | 0.2183148 | 0.1809922 | 0.1937792 | 0.1874603 | 0.3537186 | 0.2425695 | 0.1833583 |
| Mgrs/Prof. Non-Ag Labor | 0.0528389 | 0.0750194 | 0.0731323 | 0.0620557 | 0.0671114 | 0.0707292 | 0.0742985 | 0.0744455 | 0.0673985 | 0.0773067 | 0.0724853 | 0.0665394 | 0.0738689 | 0.1468188 | 0.0889291 | 0.0731878 |
| Non-Ag. Capital | 0.6473187 | 0.9398906 | 0.7818884 | 0.7820687 | 0.8055537 | 0.8790417 | 0.8485572 | 0.8411188 | 0.8284506 | 0.8827954 | 1.105148 | 0.9385045 | 0.8343245 | 0.8277292 | 0.8780472 | 0.8212168 |
| Rural Capitalists | 0.0732136 | 0.0883495 | 0.2341343 | 0.2229389 | 0.081719 | 0.0879615 | 0.1059501 | 0.1104089 | 0.070856 | 0.0629827 | 0.0497043 | 0.0512104 | 0.0985512 | 0.0694878 | 0.0699261 | 0.1113311 |
| Rural Sm. Producers | 0.0470126 | 0.0568277 | 0.1446548 | 0.137927 | 0.0525309 | 0.0565506 | 0.0679086 | 0.070637 | 0.0461044 | 0.0405594 | 0.0321569 | 0.0330735 | 0.0632536 | 0.0449171 | 0.0454629 | 0.0714171 |
| Rural Workers/Tenant Farmers | 0.0129328 | 0.0157255 | 0.0334095 | 0.0320694 | 0.0145056 | 0.0156221 | 0.0185419 | 0.0191416 | 0.0132747 | 0.011261 | 0.0090777 | 0.0092797 | 0.017368 | 0.0126298 | 0.0130445 | 0.0195766 |
| Rural Mgrs./Prof | 0.0125591 | 0.0151699 | 0.0408155 | 0.0388535 | 0.0140267 | 0.0150993 | 0.0181873 | 0.018967 | 0.0122342 | 0.0108368 | 0.0085631 | 0.0088162 | 0.0169088 | 0.0119871 | 0.0120863 | 0.0190876 |
| Urban Capitalists | 0.333821 | 0.4660833 | 0.3812063 | 0.3815502 | 0.4055253 | 0.441255 | 0.4436818 | 0.4411403 | 0.395279 | 0.4155844 | 0.495218 | 0.428697 | 0.4333183 | 0.3941533 | 0.4121928 | 0.4419339 |
| Urban Mgrs./Prof. | 0.1344603 | 0.1849679 | 0.1615522 | 0.1506568 | 0.1641233 | 0.1760186 | 0.184075 | 0.1838771 | 0.1571508 | 0.1703361 | 0.1775125 | 0.1594633 | 0.1804559 | 0.2358251 | 0.1808792 | 0.1851987 |
| Urban Sm. Producers | 0.3059765 | 0.4324983 | 0.3510207 | 0.3611435 | 0.3768679 | 0.4087642 | 0.413874 | 0.4132621 | 0.3657511 | 0.3870429 | 0.4398617 | 0.3901967 | 0.4025833 | 0.4129681 | 0.3938218 | 0.4106944 |
| Urban Organized Workers | 0.1662135 | 0.2469734 | 0.1950542 | 0.2303123 | 0.2176121 | 0.2315963 | 0.2434665 | 0.2487489 | 0.2060071 | 0.2234688 | 0.199932 | 0.2021341 | 0.2338413 | 0.3716311 | 0.2584924 | 0.2388371 |
| Urban Non-Organized Workers | 0.1537646 | 0.225264 | 0.1810745 | 0.2191316 | 0.1999368 | 0.2112479 | 0.2244495 | 0.2309254 | 0.1877085 | 0.2018768 | 0.1822262 | 0.1829236 | 0.2174582 | 0.3581334 | 0.2418915 | 0.2221755 |
| Export Agriculture | 0.1641334 | 0.1951404 | 0.1513433 | 0.1523989 | 0.1814314 | 0.1950665 | 0.2299587 | 0.2313131 | 0.1445935 | 0.1323216 | 0.1038745 | 0.1079278 | 0.2190632 | 0.1385544 | 0.1372969 | 0.2515494 |
| Traditional Agriculture | 0.1452099 | 0.1764936 | 0.8491364 | 0.7991914 | 0.1628566 | 0.1754101 | 0.2180558 | 0.2358325 | 0.1449255 | 0.1312893 | 0.1019605 | 0.1049962 | 0.1974133 | 0.1484988 | 0.1482034 | 0.2200575 |
| Livestock | 0.0390925 | 0.0488914 | 0.0497449 | 0.0500633 | 0.044652 | 0.0481868 | 0.0548864 | 0.0554742 | 0.0484649 | 0.0360543 | 0.0308581 | 0.0307977 | 0.0522385 | 0.0427956 | 0.0475349 | 0.0581696 |
| Mineral Extraction | 0.0162844 | 0.0203329 | 0.0188807 | 0.0188286 | 0.0185606 | 0.0202967 | 0.0231516 | 0.0232212 | 0.0196063 | 0.0345363 | 0.0126189 | 0.0123285 | 0.0220437 | 0.0159956 | 0.0171614 | 0.0245385 |
| Non-Mineral Extraction | 0.0480955 | 0.2555424 | 0.0456219 | 0.045981 | 0.1754843 | 0.2655827 | 0.1880364 | 0.1543855 | 0.2358895 | 0.0440769 | 0.0321141 | 0.0505206 | 0.0668307 | 0.0485142 | 0.0410635 | 0.0730781 |
| Durable Consumer Goods | 0.229689 | 0.2770137 | 0.2203264 | 0.2210652 | 0.2561126 | 0.275658 | 0.3210953 | 0.3227497 | 0.1989855 | 0.2324343 | 0.1623732 | 0.163683 | 0.3084098 | 0.203834 | 0.2026153 | 0.3487792 |
| Non-Durable Consumer Goods | 0.641009 | 0.8014281 | 0.6679763 | 0.6839274 | 0.7319199 | 0.7899548 | 0.8966571 | 0.9028396 | 0.8073789 | 0.5859459 | 0.5043547 | 0.5032876 | 0.8551494 | 0.6965062 | 0.7631811 | 0.9534556 |
| Intermediate Goods | 0.8155971 | 1.001901 | 0.8408425 | 0.8423321 | 0.9193321 | 1.001181 | 1.151501 | 1.154375 | 0.960844 | 1.191916 | 0.5974845 | 0.6072348 | 1.103504 | 0.7696738 | 0.830565 | 1.232765 |
| Capital Goods | 0.1392339 | 0.1857667 | 0.1496105 | 0.1499912 | 0.1652144 | 0.1862317 | 0.2022557 | 0.1979489 | 0.2099565 | 0.1891424 | 0.105131 | 0.1077825 | 0.2004594 | 0.1539603 | 0.2017291 | 0.2056305 |
| Coal (Coal Steam and Coke) | 0.0166764 | 0.0199532 | 0.0155761 | 0.0156322 | 0.0184987 | 0.0199827 | 0.0234409 | 0.0235328 | 0.0157035 | 0.0167936 | 0.0107753 | 0.0111809 | 0.0224609 | 0.0141691 | 0.014261 | 0.0255242 |
| Bagasse | 0.0128033 | 0.01563 | 0.0128611 | 0.0129258 | 0.0143937 | 0.0155903 | 0.0180116 | 0.0180761 | 0.0139997 | 0.0160415 | 0.0091531 | 0.0094525 | 0.0212185 | 0.0119259 | 0.0122185 | 0.0193573 |
| Kerosene | 0.0062129 | 0.0073872 | 0.0056827 | 0.0057276 | 0.0068739 | 0.0073796 | 0.008698 | 0.0087476 | 0.0052962 | 0.0049893 | 0.0039377 | 0.0048726 | 0.0099272 | 0.0054391 | 0.0048899 | 0.0095099 |
| Oil (diesel, fuel, naphtha) | 1.106845 | 0.0962233 | 0.0772109 | 0.0775616 | 0.0890947 | 0.09615 | 0.1124886 | 0.1130137 | 0.0701561 | 0.0727616 | 0.0514348 | 0.068124 | 0.1246156 | 0.0697409 | 0.0638596 | 0.1219988 |
| Gasoline | 0.0174427 | 1.020686 | 0.0156959 | 0.015778 | 0.019254 | 0.0206791 | 0.0244009 | 0.024531 | 0.0145145 | 0.013882 | 0.0110454 | 0.0115173 | 0.0254987 | 0.0143724 | 0.0135686 | 0.0267306 |
| Ethanol-M | 0.0015132 | 0.0018772 | 1.001515 | 0.0015253 | 0.0017202 | 0.0018472 | 0.0020976 | 0.0021065 | 0.0014683 | 0.0013738 | 0.0012442 | 0.0012499 | 0.0031633 | 0.0014865 | 0.0013719 | 0.0022394 |
| Ethanol-T | 0.0015564 | 0.0019271 | 0.0015536 | 1.001564 | 0.0017674 | 0.0018975 | 0.0021585 | 0.0021678 | 0.0015051 | 0.0014049 | 0.001265 | 0.0012753 | 0.0032724 | 0.0015212 | 0.0014026 | 0.0023066 |
| Gas (LPG,city gas, natural gas) | 0.0173366 | 0.0216082 | 0.0166617 | 0.0169797 | 1.019776 | 0.0214387 | 0.0245209 | 0.0245992 | 0.0165211 | 0.0152528 | 0.0125405 | 0.0337928 | 0.0231505 | 0.0168696 | 0.0151315 | 0.0261854 |
| Electricity | 0.1267287 | 0.1527827 | 0.1208153 | 0.1218737 | 0.1413937 | 1.165495 | 0.1778743 | 0.1788279 | 0.113237 | 0.1175403 | 0.0861616 | 0.1394594 | 0.1779255 | 0.1377792 | 0.1113066 | 0.1931273 |
| Fuelwood | 0.071195 | 0.0843636 | 0.0679915 | 0.0681494 | 0.0785367 | 0.0844192 | 1.099842 | 0.1004872 | 0.0598844 | 0.059293 | 0.0444056 | 0.0562773 | 0.0952901 | 0.0588315 | 0.0560199 | 0.1093561 |
| Veg. Charcoal | 0.0352916 | 0.0423898 | 0.0325759 | 0.0330123 | 0.0392831 | 0.0422417 | 0.0494528 | 1.049743 | 0.0308041 | 0.0291438 | 0.0233702 | 0.0491243 | 0.0471049 | 0.0311253 | 0.0287377 | 0.0538499 |
| Other | 0.0033943 | 0.0042542 | 0.0034675 | 0.0035638 | 0.0038933 | 0.0041825 | 0.0047447 | 0.0047755 | 1.00353 | 0.003139 | 0.0027054 | 0.0080516 | 0.0070009 | 0.0036409 | 0.003185 | 0.0050381 |
| Civil Construction | 0.0166998 | 0.0241664 | 0.0305526 | 0.0308122 | 0.0210547 | 0.0247878 | 0.0246024 | 0.0244162 | 0.0263214 | 1.071147 | 0.0617613 | 0.0212754 | 0.0249346 | 0.0359823 | 0.0258496 | 0.0239136 |
| Financial/Commercial Services | 0.3856628 | 0.5568555 | 0.5093595 | 0.5254672 | 0.4848144 | 0.5471986 | 0.5569744 | 0.5568858 | 0.6818309 | 0.4848883 | 2.171128 | 0.4902043 | 0.5246339 | 0.8113502 | 0.531667 | 0.5399488 |
| Commerce | 0.1484497 | 0.210272 | 0.1872951 | 0.1999262 | 0.1847863 | 0.2003347 | 0.2082021 | 0.21001 | 0.2141756 | 0.1855731 | 0.177727 | 1.180213 | 0.1987207 | 0.242756 | 0.1967718 | 0.206045 |
| Transportation/Communication | 1.067494 | 1.286547 | 1.014879 | 1.0273 | 1.193642 | 1.278428 | 1.490752 | 1.499426 | 0.9834344 | 0.8847224 | 0.7247711 | 0.7745535 | 2.429868 | 0.9677909 | 0.8796931 | 1.614837 |
| Public Services | 0.0254183 | 0.0320535 | 0.0271583 | 0.0275509 | 0.0291734 | 0.0315034 | 0.0352679 | 0.0353749 | 0.0263027 | 0.0243699 | 0.0210519 | 0.0220628 | 0.0334896 | 1.048213 | 0.026343 | 0.0369803 |
| Private Services | 0.2185625 | 0.303306 | 0.2939371 | 0.2971228 | 0.2667096 | 0.2911689 | 0.3037283 | 0.3044574 | 0.2812879 | 0.2742765 | 0.2888208 | 0.2628667 | 0.3031431 | 0.3527057 | 1.299978 | 0.3028132 |
| Carbon Dioxide Pollution | 2.757358 | 3.242489 | 2.430624 | 2.44165 | 3.026742 | 3.251141 | 3.863249 | 3.884486 | 2.222594 | 2.138453 | 1.653269 | 1.737275 | 3.678997 | 2.18871 | 2.079673 | 4.251773 |

Social Accounting Matrix SAM-TECH, Brazil, 1985
Total Employment Multiplier



| | | ei/Xi | (ei/Xi)(x(j)) Ag-Export A101 | Ag-Trad A102 | Livestock A103 | Minerals A104 | Non-min A105 | Cons-Dur A106 | Con-ND A107 | Intermed A108 | Capital A109 | Coal E110-1 | Bagasse E110-2 | Kerosene E110-3 | Oil E110-4 | Gasoline E110-5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Export Agriculture | A101 | 7.928E-06 | 9.668E-06 | 9.519E-06 | 1.071E-06 | 8.833E-07 | 9.402E-07 | 1.726E-06 | 1.915E-06 | 1.476E-06 | 1.31E-06 | 1.567E-06 | 1.133E-06 | 1.441E-06 | 1.301E-06 | 1.547E-06 |
| Traditional Agriculture | A102 | 7.93E-06 | 1.553E-06 | 4.409E-07 | 1.606E-06 | 8.713E-07 | 9.323E-07 | 1.48E-06 | 2.006E-06 | 1.498E-06 | 1.249E-06 | 1.417E-06 | 6.111E-06 | 1.294E-06 | 1.151E-06 | 1.399E-06 |
| Livestock | A103 | 7.928E-06 | 4.461E-07 | 1.654E-07 | 8.374E-06 | 2.576E-07 | 2.825E-07 | 3.992E-07 | 8.743E-07 | 3.731E-07 | 3.433E-07 | 3.943E-07 | 3.665E-07 | 3.559E-07 | 3.099E-07 | 3.876E-07 |
| Mineral Extraction | A104 | 8.316E-07 | 1.843E-08 | 4.135E-08 | 1.878E-08 | 8.995E-07 | 1.307E-08 | 1.96E-08 | 2.165E-08 | 3.418E-08 | 2.081E-08 | 2.018E-08 | 1.442E-08 | 1.519E-08 | 1.354E-08 | 1.691E-08 |
| Non-Mineral Extraction | A105 | 2.453E-06 | 1.58E-07 | 1.22E-07 | 1.064E-07 | 9.988E-08 | 2.548E-06 | 1.531E-07 | 1.482E-07 | 1.49E-07 | 1.282E-07 | 3.817E-07 | 1.79E-07 | 1.308E-07 | 1.18E-07 | 6.269E-07 |
| Durable Consumer Goods | A106 | 8.633E-07 | 2.649E-07 | 2.06E-07 | 1.725E-07 | 1.501E-07 | 1.562E-07 | 1.175E-06 | 2.443E-07 | 2.282E-07 | 2.145E-07 | 2.446E-07 | 1.803E-07 | 2.197E-07 | 1.983E-07 | 2.392E-07 |
| Non-Durable Consumer Goods | A107 | 7.302E-07 | 6.245E-07 | 5.052E-07 | 4.591E-07 | 3.873E-07 | 4.249E-07 | 6.01E-07 | 1.378E-06 | 5.546E-07 | 5.158E-07 | 5.959E-07 | 4.554E-07 | 5.376E-07 | 4.681E-07 | 5.852E-07 |
| Intermediate Goods | A108 | 5.687E-07 | 6.338E-07 | 5.156E-07 | 5.034E-07 | 3.928E-07 | 4.073E-07 | 6.633E-07 | 6.386E-07 | 1.326E-06 | 6.826E-07 | 5.801E-07 | 4.41E-07 | 5.176E-07 | 4.638E-07 | 5.698E-07 |
| Capital Goods | A109 | 7.34E-07 | 1.34E-07 | 1.07E-07 | 9.234E-08 | 1.137E-07 | 1.362E-07 | 1.93E-07 | 1.297E-07 | 1.321E-07 | 9.741E-07 | 1.404E-07 | 9.658E-08 | 1.12E-07 | 1.022E-07 | 1.363E-07 |
| Coal (Coal Steam and Coke) | E110-1 | 9.452E-07 | 2.109E-08 | 1.606E-08 | 1.369E-08 | 1.137E-08 | 1.198E-08 | 2.084E-08 | 1.988E-08 | 2.632E-08 | 2.098E-08 | 9.643E-07 | 1.379E-08 | 1.741E-08 | 1.576E-08 | 1.886E-08 |
| Bagasse | E110-2 | 4.085E-07 | 7.072E-09 | 5.648E-09 | 5.274E-09 | 4.223E-09 | 4.417E-09 | 7.19E-09 | 6.929E-09 | 1.198E-08 | 6.935E-09 | 6.498E-09 | 7.225E-07 | 5.867E-09 | 5.23E-09 | 6.384E-09 |
| Kerosene | E110-3 | 1.034E-07 | 8.528E-10 | 6.409E-10 | 5.33E-10 | 4.387E-10 | 4.656E-10 | 8.084E-10 | 7.808E-10 | 7.215E-10 | 6.536E-10 | 7.738E-10 | 5.622E-10 | 1.041E-07 | 6.425E-10 | 7.64E-10 |
| Oil (diesel, fuel, naphtha) | E110-4 | 1.422E-07 | 1.542E-08 | 1.215E-08 | 9.378E-09 | 1.067E-08 | 9.147E-09 | 1.435E-08 | 1.399E-08 | 1.311E-08 | 1.181E-08 | 1.379E-08 | 1.048E-08 | 1.262E-08 | 1.574E-07 | 1.368E-08 |
| Gasoline | E110-5 | 5.46E-08 | 1.26E-09 | 9.347E-10 | 7.444E-10 | 6.468E-10 | 6.818E-10 | 1.195E-09 | 1.148E-09 | 1.066E-09 | 9.507E-10 | 1.143E-09 | 8.158E-10 | 1.052E-09 | 9.525E-10 | 5.573E-08 |
| Ethanol-M | E110-6 | 9.875E-08 | 1.956E-10 | 1.542E-10 | 1.326E-10 | 1.292E-10 | 1.344E-10 | 1.908E-10 | 1.853E-10 | 1.752E-10 | 1.623E-10 | 1.876E-10 | 1.452E-10 | 1.695E-10 | 1.494E-10 | 1.854E-10 |
| Ethanol-[illegible] | E110-7 | 2.794E-07 | 5.698E-10 | 4.482E-10 | 3.85E-10 | 3.722E-10 | 3.876E-10 | 5.549E-10 | 5.388E-10 | 5.089E-10 | 4.706E-10 | 5.453E-10 | 4.214E-10 | 4.933E-10 | 4.349E-10 | 5.385E-10 |
| Gas (LPG,city gas, natural gas) | E110-8 | 3.818E-07 | 8.756E-09 | 6.735E-09 | 5.708E-09 | 5.206E-09 | 6.312E-09 | 8.531E-09 | 8.249E-09 | 7.763E-09 | 7.225E-09 | 8.252E-09 | 6.186E-09 | 7.459E-09 | 6.62E-09 | 8.251E-09 |
| Electricity | E110-9 | 5.184E-07 | 8.821E-08 | 6.811E-08 | 5.856E-08 | 6.165E-08 | 5.175E-08 | 8.625E-08 | 8.314E-08 | 7.799E-08 | 7.131E-08 | 8.004E-08 | 5.98E-08 | 7.318E-08 | 6.57E-08 | 7.92E-08 |
| Fuelwood | E110-10 | 7.928E-06 | 7.705E-07 | 6.022E-07 | 5.638E-07 | 3.932E-07 | 4.019E-07 | 7.112E-07 | 7.076E-07 | 6.528E-07 | 5.688E-07 | 6.766E-07 | 5.101E-07 | 6.232E-07 | 5.644E-07 | 6.689E-07 |
| Veg. Charcoal | E110-11 | 7.928E-06 | 3.705E-07 | 2.787E-07 | 2.283E-07 | 2.092E-07 | 2.139E-07 | 3.555E-07 | 3.42E-07 | 3.19E-07 | 2.895E-07 | 3.396E-07 | 2.48E-07 | 3.118E-07 | 2.798E-07 | 3.361E-07 |
| Other | E110-12 | 1.205E-06 | 5.396E-09 | 4.299E-09 | 3.798E-09 | 3.541E-09 | 3.818E-09 | 5.333E-09 | 5.169E-09 | 4.882E-09 | 4.635E-09 | 5.196E-09 | 4.142E-09 | 4.742E-09 | 4.09E-09 | 5.126E-09 |
| Civil Construction | A111 | 1.661E-06 | 3.723E-08 | 3.325E-08 | 3.283E-08 | 3.79E-08 | 4.847E-08 | 4.065E-08 | 3.974E-08 | 3.948E-08 | 4.085E-08 | 4.372E-08 | 3.407E-08 | 3.367E-08 | 2.774E-08 | 4.014E-08 |
| Financial/Commercial Services | A112 | 9.91E-07 | 5.139E-07 | 4.82E-07 | 4.919E-07 | 5.208E-07 | 6.175E-07 | 5.494E-07 | 5.412E-07 | 5.331E-07 | 5.422E-07 | 5.382E-07 | 5.146E-07 | 4.824E-07 | 3.822E-07 | 5.519E-07 |
| Commerce | A113 | 1.83E-06 | 3.546E-07 | 3.185E-07 | 3.222E-07 | 3.623E-07 | 3.982E-07 | 3.923E-07 | 3.84E-07 | 3.78E-07 | 4.026E-07 | 3.862E-07 | 3.557E-07 | 3.386E-07 | 2.716E-07 | 3.847E-07 |
| Transportation/Communication | A114 | 1.511E-06 | 2.134E-06 | 1.638E-06 | 1.375E-06 | 1.174E-06 | 1.252E-06 | 2.036E-06 | 1.967E-06 | 1.831E-06 | 1.662E-06 | 1.977E-06 | 1.492E-06 | 1.829E-06 | 1.613E-06 | 1.944E-06 |
| Public Services | A115 | 1.756E-06 | 5.893E-08 | 4.917E-08 | 4.551E-08 | 4.407E-08 | 4.528E-08 | 5.817E-08 | 5.724E-08 | 5.682E-08 | 5.236E-08 | 5.713E-08 | 4.738E-08 | 5.031E-08 | 4.464E-08 | 5.63E-08 |
| Private Services | A116 | 4.391E-06 | 1.314E-06 | 1.289E-06 | 1.313E-06 | 1.32E-06 | 1.374E-06 | 1.331E-06 | 1.339E-06 | 1.29E-06 | 1.305E-06 | 1.327E-06 | 1.268E-06 | 1.128E-06 | 9.597E-07 | 1.332E-06 |
| Sum | Sum | 6.21E-05 | 1.92E-05 | 1.643E-05 | 1.688E-05 | 8.215E-06 | 1.028E-05 | 1.203E-05 | 1.287E-05 | 1.102E-05 | 1.043E-05 | 1.177E-05 | 1.427E-05 | 9.647E-06 | 8.527E-06 | 1.101E-05 |
| Sum * 1000000 | 1000000 | 62.099515 | 19.203453 | 16.428061 | 16.875672 | 8.2150351 | 10.280251 | 12.029778 | 12.873386 | 11.016065 | 10.426016 | 11.766573 | 14.265636 | 9.6473929 | 8.5265078 | 11.010816 |

Social Accounting Matrix SAM-TECH, Brazil, 1985
Total Employment Multiplier

| | | Ethanol-M E110-6 | Ethanol-T E110-7 | Gas E110-8 | Electricity E110-9 | Fuelwood E110-10 | Veg Char E110-11 | Other E110-12 | Construct A111 | Financial A112 | Commerce A113 | Transport A114 | Public A115 | Private A116 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Export Agriculture | A101 | 1.2E-06 | 1.208E-06 | 1.438E-06 | 1.547E-06 | 1.823E-06 | 1.834E-06 | 1.146E-06 | 1.049E-06 | 8.235E-07 | 8.557E-07 | 1.737E-06 | 1.098E-06 | 1.089E-06 |
| Traditional Agriculture | A102 | 6.732E-06 | 6.336E-06 | 1.291E-06 | 1.391E-06 | 1.729E-06 | 1.87E-06 | 1.149E-06 | 1.041E-06 | 8.084E-07 | 8.324E-07 | 1.565E-06 | 1.177E-06 | 1.175E-06 |
| Livestock | A103 | 3.944E-07 | 3.969E-07 | 3.54E-07 | 3.82E-07 | 4.351E-07 | 4.398E-07 | 3.842E-07 | 2.858E-07 | 2.446E-07 | 2.442E-07 | 4.142E-07 | 3.393E-07 | 3.769E-07 |
| Mineral Extraction | A104 | 1.57E-08 | 1.566E-08 | 1.544E-08 | 1.688E-08 | 1.925E-08 | 1.931E-08 | 1.631E-08 | 2.872E-08 | 1.049E-08 | 1.025E-08 | 1.833E-08 | 1.33E-08 | 1.427E-08 |
| Non-Mineral Extraction | A105 | 1.119E-07 | 1.128E-07 | 4.305E-07 | 6.516E-07 | 4.613E-07 | 3.788E-07 | 5.787E-07 | 1.081E-07 | 7.879E-08 | 1.239E-07 | 1.64E-07 | 1.19E-07 | 1.007E-07 |
| Durable Consumer Goods | A106 | 1.902E-07 | 1.909E-07 | 2.211E-07 | 2.38E-07 | 2.772E-07 | 2.786E-07 | 1.718E-07 | 2.007E-07 | 1.402E-07 | 1.413E-07 | 2.663E-07 | 1.76E-07 | 1.749E-07 |
| Non-Durable Consumer Goods | A107 | 4.878E-07 | 4.994E-07 | 5.345E-07 | 5.768E-07 | 6.547E-07 | 6.593E-07 | 5.896E-07 | 4.279E-07 | 3.683E-07 | 3.675E-07 | 6.244E-07 | 5.086E-07 | 5.573E-07 |
| Intermediate Goods | A108 | 4.782E-07 | 4.79E-07 | 5.228E-07 | 5.694E-07 | 6.549E-07 | 6.565E-07 | 5.464E-07 | 6.778E-07 | 3.398E-07 | 3.453E-07 | 6.276E-07 | 4.377E-07 | 4.723E-07 |
| Capital Goods | A109 | 1.098E-07 | 1.101E-07 | 1.213E-07 | 1.367E-07 | 1.484E-07 | 1.453E-07 | 1.541E-07 | 1.388E-07 | 7.716E-08 | 7.911E-08 | 1.471E-07 | 1.13E-07 | 1.481E-07 |
| Coal (Coal Steam and Coke) | E110-1 | 1.472E-08 | 1.478E-08 | 1.749E-08 | 1.889E-08 | 2.216E-08 | 2.224E-08 | 1.484E-08 | 1.587E-08 | 1.019E-08 | 1.057E-08 | 2.123E-08 | 1.339E-08 | 1.348E-08 |
| Bagasse | E110-2 | 5.253E-09 | 5.28E-09 | 5.879E-09 | 6.368E-09 | 7.357E-09 | 7.384E-09 | 5.719E-09 | 6.553E-09 | 3.739E-09 | 3.861E-09 | 8.667E-09 | 4.871E-09 | 4.991E-09 |
| Kerosene | E110-3 | 5.877E-10 | 5.923E-10 | 7.109E-10 | 7.632E-10 | 8.995E-10 | 9.047E-10 | 5.477E-10 | 5.16E-10 | 4.072E-10 | 5.039E-10 | 1.027E-09 | 5.625E-10 | 5.057E-10 |
| Oil (diesel, fuel, naphtha) | E110-4 | 1.098E-08 | 1.103E-08 | 1.267E-08 | 1.367E-08 | 1.599E-08 | 1.607E-08 | 9.976E-09 | 1.035E-08 | 7.314E-09 | 9.687E-09 | 1.772E-08 | 9.917E-09 | 9.08E-09 |
| Gasoline | E110-5 | 8.571E-10 | 8.616E-10 | 1.051E-09 | 1.129E-09 | 1.332E-09 | 1.34E-09 | 7.926E-10 | 7.58E-10 | 6.031E-10 | 6.289E-10 | 1.392E-09 | 7.848E-10 | 7.409E-10 |
| Ethanol-M | E110-6 | 9.89E-08 | 1.506E-10 | 1.699E-10 | 1.824E-10 | 2.071E-10 | 2.08E-10 | 1.45E-10 | 1.357E-10 | 1.229E-10 | 1.234E-10 | 3.124E-10 | 1.468E-10 | 1.355E-10 |
| Ethanol-T | E110-7 | 4.341E-10 | 2.799E-07 | 4.939E-10 | 5.302E-10 | 6.032E-10 | 6.058E-10 | 4.206E-10 | 3.926E-10 | 3.535E-10 | 3.564E-10 | 9.144E-10 | 4.251E-10 | 3.919E-10 |
| Gas (LPG,city gas, natural gas) | E110-8 | 6.362E-09 | 6.484E-09 | 3.894E-07 | 8.186E-09 | 9.363E-09 | 9.393E-09 | 6.309E-09 | 5.824E-09 | 4.789E-09 | 1.29E-08 | 8.84E-09 | 6.442E-09 | 5.778E-09 |
| Electricity | E110-9 | 6.263E-08 | 6.318E-08 | 7.33E-08 | 6.042E-07 | 9.221E-08 | 9.271E-08 | 5.87E-08 | 6.093E-08 | 4.467E-08 | 7.23E-08 | 9.224E-08 | 7.143E-08 | 5.77E-08 |
| Fuelwood | E110-10 | 5.39E-07 | 5.403E-07 | 6.227E-07 | 6.693E-07 | 8.72E-06 | 7.967E-07 | 4.748E-07 | 4.701E-07 | 3.521E-07 | 4.462E-07 | 7.555E-07 | 4.664E-07 | 4.441E-07 |
| Veg. Charcoal | E110-11 | 2.583E-07 | 2.617E-07 | 3.114E-07 | 3.349E-07 | 3.921E-07 | 8.323E-06 | 2.441E-07 | 2.311E-07 | 1.853E-07 | 3.895E-07 | 3.735E-07 | 2.468E-07 | 2.278E-07 |
| Other | E110-12 | 4.178E-09 | 4.294E-09 | 4.692E-09 | 5.04E-09 | 5.717E-09 | 5.755E-09 | 1.209E-06 | 3.783E-09 | 3.26E-09 | 9.702E-09 | 8.436E-09 | 4.387E-09 | 3.838E-09 |
| *Civil Construction* | *A111* | 5.075E-08 | 5.118E-08 | 3.498E-08 | 4.118E-08 | 4.087E-08 | 4.056E-08 | 4.372E-08 | 1.779E-06 | 1.026E-07 | 3.534E-08 | 4.142E-08 | 5.977E-08 | 4.294E-08 |
| *Financial/Commercial Services* | *A112* | *5.048E-07* | *5.208E-07* | *4.805E-07* | *5.423E-07* | *5.52E-07* | *5.519E-07* | *6.758E-07* | *4.806E-07* | *2.152E-06* | *4.859E-07* | *5.2E-07* | *8.042E-07* | *5.27E-07* |
| *Commerce* | *A113* | *3.427E-07* | *3.658E-07* | *3.381E-07* | *3.665E-07* | *3.809E-07* | *3.842E-07* | *3.919E-07* | *3.395E-07* | *3.252E-07* | *2.159E-06* | *3.636E-07* | *4.442E-07* | *3.6E-07* |
| Transportation/Communication | A114 | 1.534E-06 | 1.552E-06 | 1.804E-06 | 1.932E-06 | 2.253E-06 | 2.266E-06 | 1.486E-06 | 1.337E-06 | 1.095E-06 | 1.17E-06 | 3.672E-06 | 1.462E-06 | 1.329E-06 |
| Public Services | A115 | 4.77E-08 | 4.839E-08 | 5.124E-08 | 5.533E-08 | 6.194E-08 | 6.213E-08 | 4.62E-08 | 4.28E-08 | 3.697E-08 | 3.875E-08 | 5.882E-08 | 1.841E-06 | 4.627E-08 |
| Private Services | A116 | 1.291E-06 | 1.305E-06 | 1.171E-06 | 1.278E-06 | 1.334E-06 | 1.337E-06 | 1.235E-06 | 1.204E-06 | 1.268E-06 | 1.154E-06 | 1.331E-06 | 1.549E-06 | 5.708E-06 |
| 0 | 0 | 1.449E-05 | 1.438E-05 | 1.025E-05 | 1.139E-05 | 2.009E-05 | 2.02E-05 | 1.064E-05 | 9.948E-06 | 8.484E-06 | 9E-06 | 1.284E-05 | 1.097E-05 | 1.289E-05 |
| 0 | 0 | 14.492292 | 14.380737 | 10.248643 | 11.387289 | 20.092538 | 20.198389 | 10.640853 | 9.9475116 | 8.4839301 | 8.9998678 | 12.8399 | 10.968392 | 12.889907 |

# IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6″

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