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## ECONOMIC ANALYSIS OF BRAZILIAN GOVERNMENT'S ROLE IN AMAZON AGRICULTURAL ENTERPRISES

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### Abstract

The purpose of this study was to examine the effects of Brazilian government policies on Amazon agricultural production to determine the link between these policies and the increasing rate of deforestation. Using a combination of production theory and economic models, the study's results showed that acreage expansion induced by government incentives, rather than technological improvement, has been the main factor in the continued output growth for crops. The cattle industry was also examined because of its role in deforestation. The study's results showed that subsidized credit and world beef prices had a significant impact on the expansion of the cattle industry.

### Problem Statement

Brazil has been at the center of controversy over its increasing rate of deforestation of the Amazon. Recent studies have shown that the annual clearing rate ranged from 10 to 16 thousand square kilometers per year (Denevan, 1981). The high deforestation rate has been hypothesized to be attributed to Brazilian government policies aimed at promoting economic growth and protecting Brazilian territory. The recent heightened global awareness of the existing and potential impacts of deforestation to global climatic changes, and the loss of valuable genetic resources, has made Brazil the subject of substantial criticism. The international community has been critical of Brazil, which controls 33 percent of the world's tropical rainforest, because it continued to promote economic development through continued deforestation. As a result, pressure has been put on international lending institutions to decrease the lending to Brazil, until Brazil formulates a better environmental policy towards developing the Amazon.

Incorporating acceptable environmental elements into development projects are particularly challenging for developing countries where policy options, funding, and expertise are often extremely limited. Currently, Brazil's economy is undergoing drastic macroeconomic policy reform to curb its persistently high inflation rate with the probable consequence of a less than optimistic short and medium-term growth. Given Brazil's economic woes, it will be useful to examine the impact of past and existing policies on Amazon development that have led to deforestation. As such, this study focuses on examining the impact of Brazilian policies that have influenced important agricultural industries in the Amazon. If some quantitative relationships can be established between government policies and agricultural production that contributes to irrational deforestation, decision makers can argue that current government programs promoting agricultural development in the Amazon

should be eliminated or redesigned.

### Objectives of this Study

The general objective of this study is to examine the impacts of governmental policies on Amazon agricultural production. Specifically, two aspects will be examined. First, the relationship between the amount of land used in crop production, focusing on its growth rate as it relates to output growth rate, will be examined. While no direct inference can be made as to how much land has been cleared, it can be hypothesized that if government programs continue to promote land clearing for crop production, then more deforestation will take place. Second, the relationship between cattle production and its major determinants, such as government subsidies and world price, that have resulted in the expansion of the cattle industry through time will be established. This quantitative approach will provide a measure of deforestation as cattle production in the Amazon requires approximately 2.5 hectares per cow (Fearnside 1986). Therefore, as cattle production increases, so does the rate of deforestation *ceteris paribus*.

### Background

Throughout Brazilian history, numerous government policies and programs were designed to promote certain agricultural industries at the expense of rainforest resources. The programs, though managed inefficiently and often designed to cater to particular interest groups, contributed to increased production of crops and cattle production in the Amazon. This section will examine the government's role in Amazon development by discussing programs that have particularly influenced the growth of the following industries: cattle, soybeans, coffee, and corn. Cattle, soybeans, and coffee were chosen because they are important export commodities that generate a large portion of revenue for the Brazilian economy. Corn production was also included because it represents an important staple crop that was heavily subsidized by the government.

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Beginning in the early sixties, Amazon agricultural development was aggressively promoted through a newly established agency called the Superintendencia do Desenvolvimento da Amazonia (SUDAM). To attract investments for the SUDAM projects, generous fiscal incentives, including tax breaks and subsidies, were provided. Cattle ranching flourished due to these incentives provided by the government who believed cattle production would improve the Brazilian economy through export revenues. Consequently, government approval rate of cattle ranching projects reached 42.7 percent of total SUDAM tax subsidies for the 1965-83 period.

Government programs have also been instrumental in promoting crop production, namely soybeans, coffee, and corn, in the Amazon. One factor identified in explaining the expansion of land used for crops into the Northern region of the Amazon was the reallocation of land from Southern Brazil from staple crops into soybeans. In order to prevent a domestic food shortage, the government actively promoted staple crop production into the Northern Amazon region so that the basic food crop production would remain high. The initial plans for this shift in the South began in the early '60s when, with the help of U.S. economic aid, Brazil formed its first soybean research station (the National Commission for Soybeans 1964). As a result of the technological advances in seed quality, harvesting, and crushing capacity, soybean production in the Central West region of Brazil, which include two major Amazon states (Mato Grosso and Goias) grew dramatically. By 1973, with a sharp increase in world soybean prices, Brazil further responded by expanding production to increase its foreign exchange earnings. In the aftermath of the soybean expansion in the South, the Amazon region began to increase staple crop production in the seventies to complement its colonization programs whose objectives were to relieve social tensions in the economically depressed Northeast and overcrowded Southern cities. In particular, corn production was promoted through input subsidies offered by various government agencies.

The coffee industry has been one that has been the most affected in terms of government intervention throughout the time period studied. From the late sixties continuing into the seventies, Brazil's main coffee producing states, in southern and central Brazil were hard hit with damaging frosts and rust disease which seriously affected its productivity levels. As a result of the damage, Brazil began a mass eradication program from 1966-73, to eliminate trees in states producing low quality coffee beans. Beginning in 1972, to revive the coffee industry, a major tree planting program was implemented in the Northern Amazon region and parts of Southern Brazil to control disease and increase productivity through the use of fertilizers and chemicals. As a result, overall national coffee production continued to remain high, staying as one of

Brazil's leading foreign exchange earnings for cash crops.

As previously mentioned, there have been numerous government programs implemented to achieve a variety of social as well as economic development goals within the Amazon region. A partial list of some of the programs that were developed include: PDAMI, PIN, PROTERRA, POLONOROESTE, PRODOESTE, POLONORDESTE (the socially oriented programs), and SUDAM, PDAMII, POLOAMAZON, EMPRAPA, PROAGRO, PRODEGRAN, DNOCS, PRODEPE, PRONAP (the economically oriented programs). These programs have been instrumental in promoting agriculture and the subsequent destruction of Amazon resources (Mahar 1989).

For this study's analysis, the Brazilian Amazon was divided into three geographic regions, in order to capture differences in producer responses that are due to climatic, geographic, market, and regional policy differences. These regions consist of the North, part of the Northeast, and a major part of the Central West. The Northern region consists of three states: Amazonas, Para, Acre, and three federal territories: Rondonia, Roraima, and Amapa. The Northeast region consists of the state of Maranhao, and the Central West region consists of two states, Mato Grosso and Goias. In 1975, for planning and policy reasons, the state of Mato Grosso was split to incorporate the northern portion in the Amazon region, and the southern portion renamed Mato Grosso do Sul, to be part of the southern region. In order to keep a consistent data series, these two states have been aggregated to represent the state of Mato Grosso.

This paper breaks the crop analysis into three time periods, the sixties, the seventies, and the eighties. These time periods were chosen because they reflect periods in which government policy and programs have impacted the growth of each of the respective industries studied.

#### Methodology

To achieve the objective which is to quantify the relationships between the crops output growth and its contributing factors of production (acreage, labor, and technology) the following production function framework was used:

$$(1) y = f(x_1, x_2, \dots, X_n, t)$$

where  $y$  = Output,  $x_i$  = inputs,  $t$  = technology

rewrite (1) in growth rate form using total differentiation and multiplying by  $Y$  we get,

$$(2) \frac{1}{Y} \frac{dY}{dt} = \sum_{i=1}^n \frac{\partial f}{\partial x_i} \frac{1}{Y} \frac{dx_i}{dt} x_i + \frac{\partial f}{\partial t} \frac{1}{Y}$$

in terms of logarithms,

$$(3) \frac{d \ln Y}{dt} = \sum_{i=1}^n \frac{\partial \ln Y}{\partial \ln x_i} \frac{d \ln x_i}{dt} + \frac{\partial \ln Y}{\partial t}$$

where  $\frac{d \ln Y}{dt}$  = growth rate of output through time

$\frac{\partial \ln Y}{\partial \ln x_i}$  = input/output elasticities (i.e. effect of  $x_i$  on Y expressed in elasticity form)

$\frac{d \ln x_i}{dt}$  = growth rate of input through time

$\frac{\partial \ln Y}{\partial t}$  = rate of technical change

by rearranging (3), the rate of technical progress can be calculated as follows:

$$(4) \frac{\partial \ln Y}{\partial t} = \frac{d \ln Y}{dt} - \sum_{i=1}^n \frac{\partial \ln Y}{\partial \ln x_i} * \frac{d \ln x_i}{dt}$$

The components of the right hand side of equation (4) are estimated parameters derived by regressing the numerator with the denominator of each component. The model to estimate the parameters has the following specification:

$$(5) \ln Z_{ij} = \alpha_{0ij} + \alpha_{1ij} * \text{time} + \alpha_{2ij} * \text{Dum70} + \alpha_{3ij} * \text{Dum80} + \alpha_{4ij} * (\text{time} * \text{Dum70}) + \alpha_{5ij} * (\text{time} * \text{Dum80}) + e_{ij}$$

where  $\ln Z_{ij}$  = natural logarithm of the numerator such as  $Y_i, X_i$ ,  
 i = crop: corn, coffee, and soybeans,  
 j = region: North, Northeast, and Central West,  
 time = year minus 1959,  
 Dum70 = 1 if year >1969 and <1981 else dum70=0,  
 Dum80 = 1 if year >1980 else Dum80=0 and,  
 $e_{ij}$  = the associated error terms

The cattle production model used in this study to examine the impact of government policies on the Amazon cattle production expansion was developed based on economic theory and prior studies by Fearnside, Mahar, Hecht and Browder. The model is disaggregated into the three regions stated earlier in order to capture the regional response differences due to policies launched at different points in time. Theoretically, production is a function of price and shifters of supply, which in this study are government credit subsidies. Evidence to support the specification of the model follows.

The inability of the United States producers to meet the domestic beef demand created a large market for international suppliers. At the same time,

the Brazilian government and international financial institutions such as the World Bank and the InterAmerican Development Bank indicated that Brazil has the potential to become a world-class beef exporter if they were provided long-term credit and better technology. They responded by infusing massive amounts of funds for livestock projects. From 1967 to 1983 tax subsidies through SUDAM increased 989 percent from \$4.05 million to \$44.2 million. Because of the explicit and implicit government and international factors' role in the evolution of ranching as the main development strategy for the Amazon, this study hypothesized beef world price and SUDAM tax credit subsidies as the major factors influencing the Amazon cattle industry.

The specification of the cattle production empirical model is:

$$\text{CATTLENO}_{it} = \beta_0 + \beta_1 * \text{WTPRICE}_t + \beta_2 * \text{GOVTSUB}_{it} + \beta_3 * \text{DUM73} + \beta_4 * \text{DUMN} + \beta_5 * \text{DUMNE} + \beta_6 * \text{PRCDUMN} + \beta_7 * \text{PRCDUMNE} + e_t$$

Positive coefficients were expected for the weighted world beef price (WTPRICE) and government credit subsidies (GOVTSUB) variables. Negative coefficient was expected of dummy variable (DUM73) due to the increase in the world petroleum price in 1973 and internal market shortages in the beef supply causing reduction in cattle numbers. There were no a priori expectations for the rest of the variables.

Ordinary Least Squares (OLS), was used to estimate the model's parameters. Where autocorrelation among the error terms was found, the Prais-Winstone remedial measure was used.

#### Data and Its Sources

To achieve the objectives of this study, data on the major agricultural enterprises' output, acreage, and labor used for crops, and the subsidized credit and beef world price for cattle are needed. Most of the data used in this study was obtained from the Anuario Estadístico do Brasil (IBGE) by state and then aggregated into the three regions, North, Northeast, and Central West. Annual time-series data for crops covering the period 1960-86 was used for this study's analysis.

For the cattle analysis, cattle numbers (CATTLENO) are in thousands; United States utility beef price (PRICE), a proxy for expected weighted world beef price (WTPRICE), is in 100 U.S. dollars per metric ton f.o.b. U.S. Gulf and weighted as follows:  $0.5 * \text{lag}_{t-3}(\text{PRICE}) + 0.3 * \text{lag}_{t-2}(\text{PRICE}) + 0.2 * \text{lag}_{t-1}(\text{PRICE})$ . SUDAM tax credit subsidy (GOVTSUB) is in 1000 U.S. dollars as reported by the World Bank; the dummy variable DUM73 = 1 for 1973 else DUM73 = 0; the dummy variables DUMN, DUMNE = 1 for the North and Northeast regions, else DUMN, DUMNE =



0; PRCDUMN and PRCDUMNE are WTPRICE-region interaction variables. The study's time period for cattle is from 1969-1985.

### Results

This section discusses the results of this study which is to examine the factors that have contributed to the growth of various Amazon agricultural enterprises. It is divided into two major sections. The first section focuses on the crop results, the second focuses on the results of the cattle production model.

Output growth rates increased throughout the study's time period with rapid growth in the '70s and a slowing of growth in the '80s. Correspondingly, acreage also grew in the same pattern suggesting that output growth was contributed largely through acreage expansion in the Amazon (see Table 1). The results also show that output growth was not due to the adoption of appropriate technologies, except for coffee production. In most cases, the contribution of technology to output growth is either zero or negative suggesting that farmers would need to expand production onto new lands each year in order to maintain the same levels of output previously experienced.

Coffee production has gained tremendous growth following the mass eradication program of the sixties, with the highest production occurring in the North. Due to the governments extensive coffee replanting program in 1972 and 1973 into the North and Northeastern regions, coffee continued to lead Brazil's export revenues. The sharp rise in output growth as shown in Table 1 (47 and 26 percent in the '70s and '80s) for the North region is due to an expansion in acreage growth (37 and 21 percent in the '70s and '80s) rather than through the use of new technologies. This is quite different from the Northeast and Central Western regions whose output growth can be attributed to some technological growth (13 and 8 percent respectively in the '70s) rather than just acreage expansion alone (see Table 1). Technological contributions in the Central West may have resulted because this region was closer to large export facilities, had better infrastructure, and had more access to better inputs and new technologies not found in the North region. The Northeast's technological contribution may have resulted from increased efforts at irrigation technologies and better use of inputs, to rescue this region from the damaging effects of drought that had plagued the region in the mid-'70s.

Soybean production in the Central West has shown a sharp rise in output growth (4, 38, 21 percent for the '60s, '70s, and '80s respectively) in response to the government's interest in expanding soybean acreage into this region in the early '70s. Output is due to the expansion of acreage (38 percent for the '60s and '70s and 19 percent in the '80s) rather than technology as is seen in the zero percent growth in technology throughout the time period. Corn production has grown

throughout time for all regions with the Northern region leading with 12 and 9 percent growth in output for the '70s and '80s respectively. The high growth in the North can be attributed to the INCRA colonization programs offering subsidies for stable crop production in the Northern region. Output expansion for all regions is due to acreage expansion rather than technology as is shown by the zero and negative growth in technology in Table 1.

The results of the parameter estimates of this study's model on cattle production are as follows:

$$\begin{aligned}
 \text{CATTLENO} &= 17752.6 + 665.3 \text{ WTPRICE} + 66.3 \text{ GOVSUB} \\
 &\quad (12.27) \quad (8.0) \quad (7.5) \\
 &\quad - 2486 \text{ DUM73} - 17557 \text{ DUMN} - 17162 \\
 \text{DUME} &\quad (2.3) \quad (9.6) \quad (9.4) \\
 &\quad - 596.3 \text{ PRCDUMN} - 685.4 \\
 \text{PRCDUMNE} &\quad (5.2) \quad (6.0)
 \end{aligned}$$

All of the estimated parameters have the expected signs, with the t-statistics shown in parenthesis, and all are significant at the 0.05 level. This indicates that government subsidies and world price did have positive impacts on cattle production in the Amazon. Moreover, there were regional differences as indicated by the significant parameters of the regional dummies and price-region interaction parameters.

Before comparing elasticities among regions, an overall statement regarding the elasticities with respect to credit and world price can be made. All of the regions in the Amazon were found to be inelastic with respect to both subsidized credit (.21 for all regions) and world price (-0.11, 0.29, and 0.31 for Northeast, North, and Central West regions, respectively).

The elasticity of cattle production with respect to credit (GOVSUB) for all regions is the same and is inelastic. The credit-region interaction terms which were dropped from the model, because the parameters were insignificant. The inelastic response of cattle production to government subsidies can be attributed to the following facts: first, in developing countries it is not uncommon that money borrowed for agricultural production purposes is actually put to other uses; second, ranching in the Amazon requires a lot of initial investment just to clear land and establish pasture so the production response to credit is expected to be inelastic.

The elasticity of cattle production with respect to world price is also inelastic. The inelastic response could be explained by the fact that Brazil has always maintained stringent controls over trade, which tends to disrupt world price transmission to domestic producers. Particularly, in the early 1970s a major government

Table 1. Annual Output, Acreage, and Technological Growth Rates for Selected Crops in the Amazon Regions.

Crop	Region <sup>1</sup>	'60s	'70s	'80s <sup>2</sup>
(Percent)				
<u>Output</u>				
Coffee	N	4.0	47.0	26.0
	NE	-12.0	24.0	-14.0
	CW	-18.0	12.0	3.0
Soybeans	CW	4.0	38.0	21.0
Corn	N	5.0	12.0	9.0
	NE*	4.0	3.0	6.0
	CW	6.0	8.0	6.0
<u>Acreage</u>				
Coffee	N	4.0	37.0	21.0
	NE	-2.0	16.0	-6.0
	CW	-15.0	12.0	2.0
Soybeans	CW	38.0	38.0	19.0
Corn	N	4.0	9.0	8.0
	NE	7.0	6.0	-2.0
	CW	7.0	6.8	3.0
<u>Technology</u>				
Coffee	N	1.3	0.0	0.0
	NE	-2.0	13.0	-1.0
	CW	23.0	8.0	24.0
Soybeans	CW	0.0	0.0	0.0
Corn	N	-2	0.0	-4.0
	NE	0.0	-2.1	0.0
	CW	0.0	0.0	0.3

<sup>1</sup> N = NORTH  
 NE = NORTHEAST  
 CW = CENTRAL WEST

<sup>2</sup> Data covers only up to 1986.

objective was to protect domestic consumers from high world prices in order to maintain real purchasing power for basic food items, including beef. When the export price was high, price controls were instituted, domestic taxes on beef lowered and/or export taxes temporarily raised, or export quotas linked to domestic supplies imposed. All of these policies have been used at least once throughout the period analyzed, sometimes several at once.

On a regional basis the Central West and the North responsiveness of cattle production to world price (0.31 and 0.29 respectively) are both inelastic. This could be explained by the fact that the cattle industry is owned mostly by large domestic corporations in those regions. The incentive for them to invest in the Amazon was the availability of tax credits such as generous tax write-offs on their non-Amazon enterprises. Additionally, corporate investors perceived cattle ranching as low risk and as having relatively low labor requirements; therefore, investment in land was considered to be the best hedge against the rampant inflation of the 1960s and 1970s.

The Northeast region's cattle production responsiveness to world price (-0.11) was negative and very inelastic. This could be due to the generally small ranching enterprises (less than 10 hectares) in the Northeast and to the fact that most of the production was for local consumption rather than for export earnings because of the limited marketing facilities.

#### Summary

The objective of this study was to establish a link between government programs and policies to agricultural development and to provide an indirect measure of deforestation within the Brazilian Amazon. The industries studied to carry out this objective were soybeans, corn, coffee, and cattle production.

The results of this study show that crop output growth was due to increasing acreage growth rather than the use of appropriate technology. As such, it can be inferred that the government programs implemented in the late '60s and '70s promoted land clearing to enhance crop production. Output growth declined in the '80s due to a cutback in government incentives (credits, subsidies) brought on by the large foreign debt and unstable economy.

Cattle production in the Amazon region has shown to be influenced by government policy, such as credit, and world price throughout the time period studied. Both credit and world price responses were inelastic in all regions. The inelastic credit response could be due to the misuse of money borrowed for cattle production, and the high rate of initial investment required to clear land for pasture development. The inelastic response to world price could be due to stringent Brazilian control over trade which often distorts world price transmission to domestic producers.

Although the parameters are inelastic they are significant, for example, if the government were to

decrease credit by one hundred thousand dollars, cattle production would drop by 21 hundred thousand head in all regions. The implications of this study have shown that it has been through the use of government policy and programs that have contributed most significantly to the increased agricultural development in the Amazon region. As shown by the expanding crop acreage growth rates and increasing cattle numbers, it can be inferred that land expansion, and subsequent forest destruction, has been allowed to increase and maintain its growth because of the abundant availability of land found within the Amazon region. Therefore, the future rate of deforestation will depend on the Brazilian policy orientation toward Amazon development.

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