PN-ABA-809

The FORESTRY PRIVATE ENTERPRISE INITIATIVE

School of Forest Resources
North Carolina State University

School of Forestry and Environmental Studies
Duke University

Office of International Cooperation and Development
Forest Service, Forestry Support Program and
Southeastern Forest Experiment Station

Supported and funded by
Bureau for Science and Technology
Agency for International Development

FPEI Working Papers Series

Southeastern Center for Forest Economics Research
Box 12254 Research Triangle Park NC 27709 Telephone 919 541-4221

Reforestation Incentives and the Economic Structure of the Charcoal Market in Minas Gerais, Brazil

By

Marc McDill

FPEI Working Paper No. 18

The Forestry Private Enterprise Initiative (FPEI) is a cooperative project of the Southeastern Center for Forest Economics Research (SCFER) with the Forestry Support Program (FSP), the United States Agency for International Development (AID) Bureau for Science and Technology (S&T) [through its Office of Forestry, Environment, (and Natural Resources (FENR)], Organization for International Cooperation and Development (OICD), the United States Department of Agriculture (USDA) Forest Service Southeastern Forest Experiment Station (SEFES), and North Carolina State University (NCSU).

The SCFER Institutions
USDA Forest Service Southeastern Forest Experiment Station
North Carolina State University Duke University

McDill, Marc. 1986. Reforestation Incentives and the Economic Structure of the Charcoal Market in Minas Gerais, Brazil. Southeastern Center for Forest Economics Research, Research Triangle Park, NC. FPEI Working Paper No. 18, 57 pp.

About the Authors

Marc McDill is a graduate research assistant and Ph.D. candidate in the School of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, VA.

About FPEI Working Papers

FPEI working papers are a special series of SCFER working papers issued by the Southeastern Center for Forest Economics Research for the purpose of sharing the research findings of the Forestry Private Enterprise Initiative. These papers are distributed in order to promote the timely release of new theories, data and findings. Working papers represent various levels of research findings and readers are encouraged to contact the author(s) for more information. Some of the papers may be published in modified form elsewhere. An updated list and copies of FPEI Working papers are available from the Center at P. O. Box 12254, Research Triangle Park, NC 27709, (919) 549-4030.

Reforestation Incentives and the Economic Structure of the Charcoal Market in Minas Gerais, Brazil

by
Marc Eric McDill

A thesis submitted to the Graduate Faculty of
North Carolina State University
in partial fulfillment of the
requirements for the Degree of
Master of Science

Department of Forestry

Raleigh

1986

Approved By:

Karen A. Ahner

Chairman of Advisory Committee

THE FORESTRY PRIVATE ENTERPRISE INITIATIVE

FPEI is a cooperative project executed by the Southeastern Center for Forest Economics Research (SCFER) in collaboration with the USDA Office of International Cooperation and Development (OICD) and the USDA Forestry Support Program (FSP). The primary members of SCFER are the USDA Forest Service Southeastern Forest Experiment Station, North Carolina State University, and Duke University. FPEI is supported and funded by the United States Agency for International Development (AID), Bureau for Science and Technology (S&T) [through its Office of Forestry, Environment, and Natural Resources (FENR)].

d

Abstract

MCDILL, MARC E. Reforestation Incentives and the Economic Structure of the Charcoal Market in Minas Gerais, Brazil. (Under the direction of Dr. Jan G. Laarman.)

This paper presents the results of a study of the Brazilian fiscal incentives for forestry and the program's effect on the charcoal market in Minas Gerais, Brazil. The incentives were intended to increase the area of industrial plantations--most of which are eucalyptus. Most of the wood produced in these eucalyptus plantations is converted to charcoal, which is then used as a reducing agent in the state's extensive iron and steel industry.

An investment model of the planting decision for eucalyptus was estimated. This model measures the effect on planting levels of the subsidy program's limits on the percentage of taxes due eligible for tax credits and attempts to measure what area might have been planted without the incentives. The results indicate that the incentives limits are negatively related to the amount of planting done--i.e., when the limits were high, less planting was done. Apparently, some other factor more effectively limited participation in the program.

Supply and demand functions for plantation-origin charcoal were estimated. Demand function estimates were inconclusive, but theoretical considerations, a previous

study (Amancio *et al*, 1983), and the provisional results obtained in this study all indicate that the demand for charcoal in Minas Gerais is price elastic. The supply of plantation-origin charcoal, on the other hand, is apparently very price inelastic. The quantity supplied is determined mostly by the amount of mature eucalyptus available--i.e., by past planting decisions. Thus, any effects the subsidy program had on the planting decision directly affected the supply of plantation-origin charcoal eight years later.

Table of Contents

LIST OF TABLES. iii

LIST OF FIGURES iv

I. Introduction 1

II. The Brazilian Forestry Incentives 2

III. Charcoal and the Iron and Steel Industry in Minas Gerais 8

IV. Model of the Charcoal Market in Minas Gerais. 13

V. Statistical Results and Discussion 24

VI. Summary and Implications. 32

BIBLIOGRAPHY. 35

APPENDIX: Data. 37

LIST OF TABLES

Table 1. Areas Planted With and Without Tax Incentives in Minas Gerais (1967-1985). 5

Table 2. Relative Prices for Charcoal and Imported Coal in Minas Gerais (1968-1985). 9

Table 3. Brazilian Pig Iron and Steel Production (1974-1984) 12

Table 4. Two-Stage Least Squares Estimation of the Demand Function (1974-1983). 26

Table 5. Two-Stage Least Squares Estimation of the Supply Function (1974-1983). 26

Table 6. Ordinary Least Squares Estimation of the Planting Decision Model (1968-1985). 29

LIST OF FIGURES

Figure 1. Plot of eucalyptus planting rates in Minas Gerais and percentage of tax liabilities eligible for tax credits from 1967 to 1985 7

Figure 2. Hypothesized structure of the charcoal market in Minas Gerais. 14

Figure 3. Model illustrating interaction effects between product prices and incentive limits on marginal planting decisions 21

I. Introduction

There is a common perception that without government intervention, private forest production would be less than socially optimal. In many countries, this perception has led to government ownership of forest land and to regulation of forest practices. Governments may also subsidize private forest production. In the United States, all three approaches are used in some form. Examples of U.S. subsidies include cost-sharing for nonindustrial private forest owners and tax breaks for industrial forestry. Forestry subsidies are also used in developing countries; in Latin America, almost all countries have some form of subsidy for private forest development (Gregersen and McGaughey, 1985, pp. 23-25).

The forestry literature is replete with justifications for such subsidization. The most plausible justifications include: (1) substantial external social costs and benefits associated with various forestry practices, and (2) the need to mitigate unique financial problems associated with forestry--such as cash flow shortages--due to the long-term nature of forestry investments (Gregersen and McGaughey, 1985, pp. 4-6). In developing countries, forest sector development is advocated because of potential foreign exchange earnings, import substitution, and the rural

orientation and labor intensive nature of forest production (Westoby, 1962).

This paper presents the results of my study of the Brazilian fiscal incentives program. The study focuses on the state of Minas Gerais where the primary species planted is eucalyptus. Most of the wood produced in these plantations is converted to charcoal, which is then used as a reducing agent in the state's extensive iron and steel industry. The primary objective of the study was to determine if and how the subsidy influenced eucalyptus planting: specifically, to determine whether the area planted was increased in response to the subsidy and how much would have been planted without it. A secondary objective was to determine how a shift in the area planted would affect the market for charcoal. This involved quantifying the link between the area planted and the supply of charcoal. Consideration of the economic structure of the charcoal market indicates how shifts in the supply of charcoal would affect the price of charcoal.

II. The Brazilian Forestry Incentives

Brazilian fiscal incentives for forestation began in 1966. The incentives allow corporations to take a tax credit for forestation expenditures up to a certain percentage of their tax liability. Individuals can also

participate in the program, but the terms for individuals are much less attractive than for corporations (Beattie, 1975, p. 33). Tax credits are allowed at a fixed rate per hectare based on government estimates of reasonable planting costs. Plantations are approved for tax credit if they meet government planting criteria and if funds are available. No specific budget limits were found for the program, but it is likely that less projects were approved during times of tight government budgets.[1] In 1967, the potential tax credit was 50% of taxes due. The effective percentage rate was reduced gradually between 1970 and 1976, and has remained at 17.5% since then (Table 1).

Under the original forestry incentives law (Law 5106),[2] forestation projects were to be completed before tax credits were approved. After 1970 (Law 1134), corporations could deposit tax liabilities to be used for forestation projects in special accounts with the Bank of Brazil and draw on these deposits as plantation projects were approved. If the funds were not spent on reforestation within a year, they were transferred back to the treasury. The new system eliminated the uncertainty of predicting future tax liabilities to determine the amount of planting to

1. Personal communication with Brazilian forestry grad students at students at NCSU.

2. Translations of the 1965 Forestry Code, Law Number 5106 of 1966, and Decree-Law 1134 of 1970 can be found in Beattie (1975), Appendix E.

undertake and of having to complete projects before approval. The new system also alleviated cash flow problems resulting from the year-long lag between plantation expenditures and release of funds from tax revenues (Beattie, 1975, pp. 41-42.)

The legislation initiating the incentives program indicates that the lawmakers' objectives were to protect native forests and to simultaneously insure an adequate supply of forest products for industry. This was to be achieved by preserving some areas as permanent parks and reserves and by stimulating the planting of vast new areas of industrial plantations.

On the surface, at least, the reforestation incentives seem to have worked in the state of Minas Gerais. As of 1985, over 1,543,000 ha. of eucalyptus and 214,000 ha. of pine have been planted with the incentives. The area of eucalyptus planted per year under the program in Minas Gerais increased from 4,859 ha. in 1967 to a peak of 194,128 ha. in 1979 (Table 1). Since 1979, the area planted per year has rapidly decreased. Table 1 also shows the area of eucalyptus planted with private funds. Finally, Table 1 lists total eucalyptus planting in Minas Gerais excluding the area planted by the pulp and paper industry. This area is assumed to have been planted for charcoal production.[3]

3. See the Appendix for a complete listing of the data and sources.

Table 1. Areas Planted With and Without Tax Incentives in Minas Gerais (1967-1985).

Year	Percentage of Taxes Due Eligible for Tax Credit	Hectares of Eucalyptus Planted With Incentives	Hectares of All Species‡ Planted With Incentives	Hectares of Eucalyptus Planted with Private Resources	Total Hectares of Eucalyptus Planted	Hectares of Eucalyptus Planted for Charcoal+
1967	50.0	4,859	4,859	---	4,859	4,859
1968	50.0	13,815	13,815	---	13,815	13,815
1969	50.0	21,079	21,079	15,189	36,268	36,268
1970	35.0	35,592	35,592	5,800	41,393	41,393
1971	30.0	36,067	48,821	49,970	86,037	83,418
1972	25.0	48,658	57,279	8,576	57,234	52,969
1973	25.0	44,582	59,041	6,428	51,010	49,750
1974	22.5	69,840	78,985	8,180	78,020	73,832
1975	20.0	114,774	138,289	7,588	122,362	114,952
1976	17.5	130,050	159,571	28,792	158,842	139,353
1977	17.5	142,888	170,944	35,843	178,731	167,746
1978	17.5	152,665	185,375	31,506	184,171	176,213
1979	17.5	164,428	194,128	36,173	200,601	194,367
1980	17.5	125,318	143,837	34,236	159,554	150,358
1981	17.5	102,409	110,956	20,528	122,937	113,613
1982	17.5	114,505	124,105	11,859	122,364	120,168
1983	17.5	57,109	59,261	15,945	73,054	68,804
1984	17.5	80,461	84,770	7,820	88,821	85,821
1985	17.5	83,447	85,591	7,984	91,431	89,170

‡ Other species include mostly pine and some fruit trees.
+ Excludes planting done by pulp and paper industry.
Source: IBDF (Brazilian Institute of Forest Development); data on pulp and paper plantings are from CENIBRA, the only pulp and paper company in Minas Gerais as of 1985.

Figure 1 shows total eucalyptus planting rates in Minas Gerais over the 1967-1985 period plotted with the changing incentive limits. This figure shows how planting rates rose sharply in spite of the decreasing limits on the percent of taxes eligible for tax credits. This relationship will be discussed at length later in the paper.

Previous evaluations of the Brazilian fiscal incentives program estimated the financial returns of the plantation investments. Beattie (1975) and Berger (1980) calculated present net worth and internal rates of return for eucalyptus and pine plantations in Minas Gerais and Sao Paulo, respectively. For example, Beattie calculated an average real rate of return of 9.1% for eucalyptus planted in Minas Gerais in 1970 (assuming a real (1973) stumpage price of Cr$ 25--the realized price, as it turns out). Beattie also provides useful background information on Brazil, the fiscal incentives program, the forest resource of Minas Gerais, and the iron and steel industry there.

Nogueira (1980) proposed planting eucalyptus in southern Bahia state and estimated the potential rate of return of such an undertaking. Nogueira also provides a description of the charcoal and iron and steel industries in Minas Gerais. Matt (1974) described the timber supply of Minas Gerais and its apparent inadequacy for meeting the charcoal requirements of the iron and steel industry. However, none of these studies of the Brazilian fiscal incentives

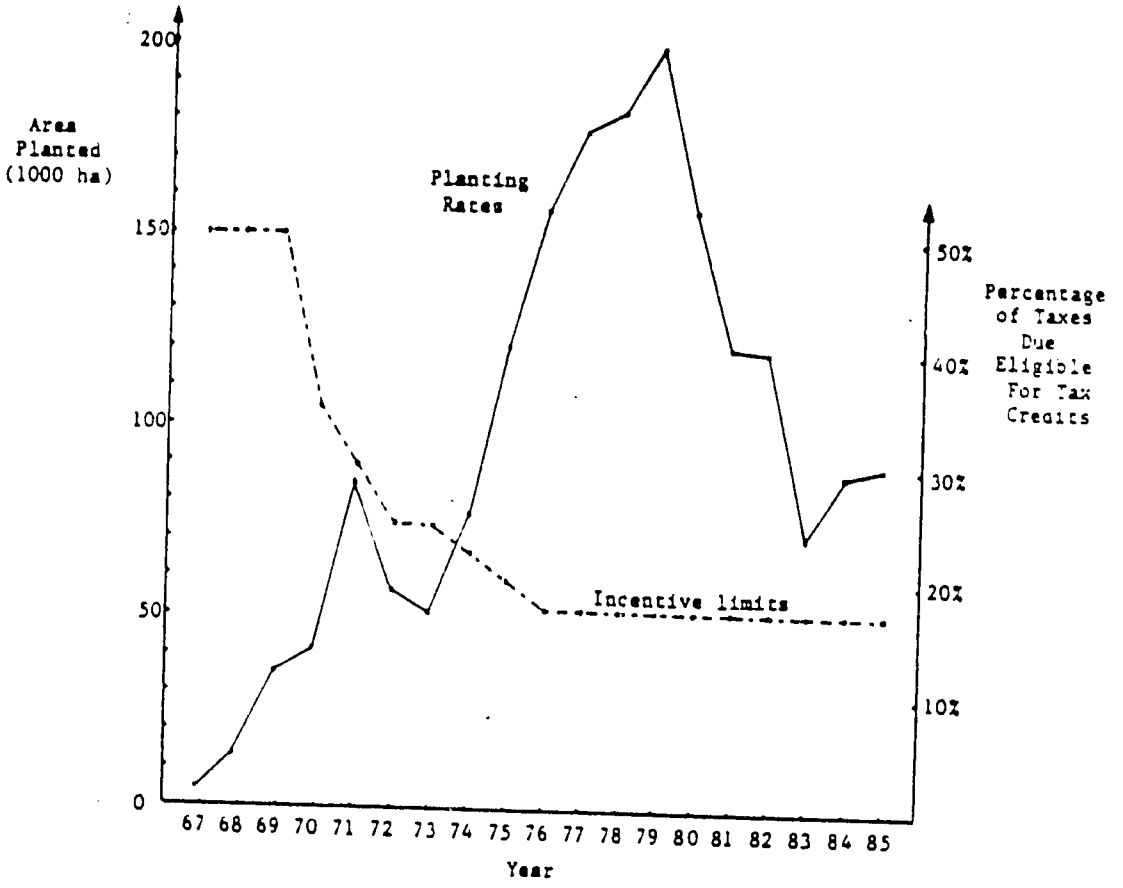

Figure 1. Plot of eucalyptus planting rates in Minas Gerais and percentage of tax liabilities eligible for tax credits from 1967 to 1985.

addresses the question of whether the program actually increased the area of eucalyptus planted.

III. Charcoal and the Iron and Steel Industry in Minas Gerais

About 30% of the Brazilian iron and steel industry uses charcoal as a reducing agent. In Minas Gerais, there are large deposits of iron ore with no nearby source of quality metallurgical coal. Some coal of poor quality is found in southern Brazil, however.

Government policies limited the use of imported coal during the early development of the industry. Thus, all the early iron and steel mills used charcoal. However, since 1941 the government-owned National Iron and Steel Company (Companhia Siderurgica Nacional) has been expanding the use of imported coal in their mills and private companies have followed suit. National coal, although low in quality, also has been increasingly utilized (Beattie, 1975, pp. 199-201).

Charcoal has a lower carbon content, by weight, than coal. Even when prices are adjusted for this factor, charcoal prices have been lower than coal prices in Minas Gerais. Table 2 shows real prices for a ton of coal and for the equivalent amount of charcoal needed to replace it. It would seem that iron and steel companies would want to buy more charcoal at these prices if it were available.

Table 2. Relative Prices for Charcoal and Imported Coal in Minas Gerais (1968-1985).

Year	Real Price of Charcoal (1980 CR$) (per m^3)	Relative Price of Charcoal* (1980 CR$)	Price of Imported Coal (cif) (1980 CR$) (per ton)	Ratio of Relative Coal and Charcoal Prices
1968	629.16	2291.93	2990.34	0.766447
1969	720.63	2625.16	3531.66	0.743321
1970	853.32	3108.54	3422.21	0.908341
1971	708.41	2580.65	4023.80	0.641347
1972	604.16	2200.86	3543.99	0.620661
1973	-	-	3290.28	-
1974	850.57	3098.52	4886.63	0.634081
1975	756.76	2756.76	4552.73	0.536236
1976	886.79	3230.46	4318.81	0.680025
1977	701.59	2555.80	4202.06	0.567669
1978	1011.38	3684.32	4239.19	0.814624
1979	857.44	3123.52	4147.74	0.753067
1980	1033.00	3763.07	4712.27	0.798568
1981	720.46	2624.54	4864.42	0.539537
1982	708.85	2582.26	5091.21	0.507199
1983	780.61	2843.64	4290.81	0.662727
1984	601.89	2192.61	3885.92	0.564243
1985	729.57	2657.74	4015.70	0.661837

* Price for amount of charcoal equivalent to one ton of coal in iron or steel manufacture: Based on 3.3 m^3 per ton, and 770 lb. carbon per ton of charcoal, compared with 850 lb. carbon per ton of coal (Beattie, 1975, p. 225).
Source: SIDERBRAS (A Brazilian public-private iron and steel company) and Beattie (1975), p. 225.

The substitutability of the two reducing agents is complicated by several factors. First, the use of charcoal limits the maximum size of blast furnaces because charcoal cannot support the large physical loads of modern large-scale blast furnaces (Beattie, 1975, p. 231). Perhaps for smaller mills, charcoal is a less expensive input, while coal is less expensive for larger mills. Second, it is expensive to actually convert a mill from one raw material to another, and conversion from charcoal to coal is only economical for the largest charcoal-burning furnaces (Beattie, 1975, p. 229). As of 1985, no such conversions had been made. However, the industry generally runs well below capacity (Nogueira, 1980, p. 31), and unused capacity can be shifted from one reducing agent to another as their relative prices vary. Third, charcoal is more expensive to handle because it is bulkier. Finally, charcoal supplies are erratic--depending on the condition of roads that are often impassable during the rainy season. Perhaps the dependability of coal may account for some premium in its price.

In view of the previous observations, different sectors within the iron and steel industry may be more responsive to shifts in the relative prices of coal and charcoal. The integrated mills produce both pig iron and steel for a variety of end uses. "Integrated" means the mills produce a range of products, but in Brazil, all the integrated mills

are also owned by public-private companies. These mills are all centrally located near Belo Horizonte, the capital of Minas Gerais. Most of the eucalyptus planting done by the iron and steel companies has been done by the companies operating the integrated mills (Nogueira, 1980, p. 61). As of 1978, these companies controlled 39% of the eucalyptus plantation area in Minas Gerais.

The independent mills produce only pig iron, and most are privately owned. They are widely scattered throughout the state and are often closer to the native forests where most of the charcoal used is produced. These mills are generally smaller and thus use more charcoal than coal, but the independent mills usually do not produce any of their own charcoal. Instead, they rely mostly on independent charcoal suppliers. The sector producing specialized iron-alloy products is relatively small compared to the pig iron and steel producing sectors. Iron alloys are made almost exclusively with charcoal.

Table 3 shows the production of pig iron, steel, and iron alloys, and the percentages of each produced with charcoal. These products correspond roughly to the three sectors mentioned above, except that pig iron is produced in both the integrated mills and the independent mills.

In the last 15 years, between 10 and 20 percent of the charcoal produced in Minas Gerais has come from eucalyptus plantations. The rest has been produced from native

Table 3. Brazilian Pig Iron and Steel Production (1974-1984).

Year	Total Brazilian Pig Iron Production (Metric Tons)	Percent of Pig Iron Produced With Charcoal	Total Brazilian Steel Production (Metric Tons)	Percent of Steel Produced With Charcoal	Total Brazilian Iron Alloys Production (Metric Tons)	Percent of Iron Alloys Produced With Charcoal	Percent of Total Iron And Steel Production Using Charcoal
1974	5,846,014	54	7,507,220	30	218,673	96	41
1975	7,052,665	51	8,308,046	30	256,671	98	41
1976	8,170,228	49	9,168,899	27	312,765	96	39
1977	9,380,372	41	11,163,755	23	372,144	98	33
1978	10,043,047	38	12,106,921	22	410,497	97	30
1979	11,713,414	39	13,891,101	20	485,149	97	29
1980	12,685,283	39	15,338,957	20	552,672	96	30
1981	10,795,530	40	13,320,460	22	564,069	96	32
1982	10,827,342	38	12,996,417	22	563,897	95	31
1983	12,944,521	37	14,670,618	19	580,723	98	29
1984	17,233,394	38	18,385,164	19	681,453	98	29

Source: ABRACAVE (The Brazilian Charcoal Producers Association.)

woodlands. While the stumpage from native forests is very cheap, these native forests have long ago been depleted in areas near the iron and steel mills. Today, native-origin charcoal must generally be transported 500 to 800 km. to the mills. As a result, freight costs make up as much as 50% of the cost of native charcoal (Beattie, 1975, p. 220).

Stumpage produced in eucalyptus plantations is relatively expensive. These plantations, however, can be located in areas nearer to the steel mills; the average transport distance from the plantations to the mills is only 55 km. (Nogueira, 1980). Therefore, a large part of the plantation-origin charcoal price is stumpage cost, while most of the native-origin charcoal price is transportation cost.

IV. Model of the Charcoal Market in Minas Gerais

Consideration of the market for plantation-origin charcoal in the context of the overall market for reducing agents suggests that the demand for plantation-origin charcoal is perfectly elastic, or at least very elastic. Figure 2 illustrates the hypothesized supply-demand structure of the market for metallurgical reducing agents in Minas Gerais. The supply functions for plantation-origin charcoal and native woodland charcoal are summed horizontally to give the industry supply function for charcoal. Since Brazil is a relatively small user in the world market for coal, it faces a perfectly elastic supply curve for imported coal. The coal supply function can be summed with the charcoal supply functions to give the supply function for all reducing agents. The demand curve for reducing agents for the iron and steel industry is also shown.

The validity of this model depends on whether charcoal and coal are actually close substitutes in metallurgy. The previous section described some of the complexities involved in substituting coal for charcoal. However, while charcoal and coal may be relatively imperfect substitutes in the short run, the growing usage of coal evident in Table 3 suggests that in the long run the two reducing agents are fairly close substitutes.

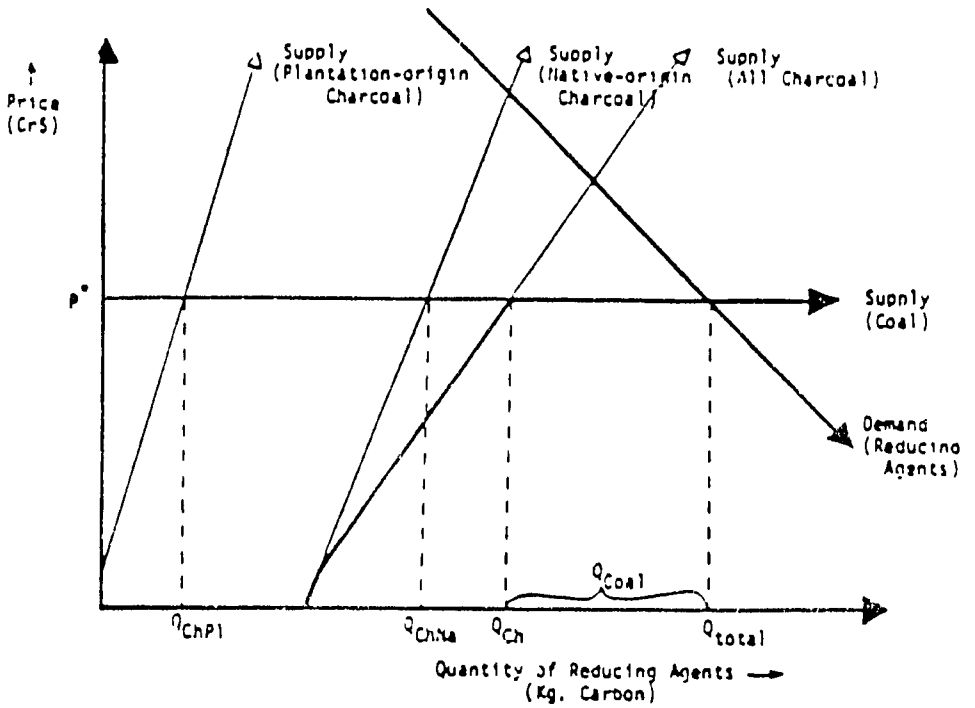

Figure 2. Hypothesized structure of the charcoal market in Minas Gerais.

In the model shown in Figure 2, coal can be viewed as a "backstop resource"[4] for the cheaper charcoal. If the price of charcoal goes higher than the price of an equivalent amount of coal, producers will switch to coal. Thus, the quantity of charcoal traded is determined by the quantity that can be delivered to the mill at a lower price than coal, and the price of coal sets the maximum price for charcoal. The charcoal price will only be less than the price of coal when the quantity of charcoal supplied is greater than Q_{Total}, and no coal would be used. However, the data in Table 3 indicate that the proportion of iron and

4. Fisher (1981) discusses the concept of a "backstop resource" and the origins of the idea.

steel produced with charcoal has been declining and is now less than 30%, so it is not likely that the quantity of charcoal supplied will exceed Q_{Total}.

In other words, because coal is a close substitute for charcoal in the long run, and because the supply of coal is perfectly elastic, the resulting demand curve for charcoal is perfectly elastic. If the charcoal demand is perfectly price elastic, shifts in the supply of charcoal will have no effect on the price of charcoal; supply shifts will result in quantity changes only. Since plantation-origin charcoal makes up only 10-20% of the total supply of charcoal, the demand for this type of charcoal should be particularly elastic.

It was not possible with the data I was able to obtain to verify this model. I had no information on the demand for reducing agents in the Minas Gerais iron and steel industry. Data were available to allow me to estimate the demand and supply functions for plantation-origin charcoal, but not for native-origin charcoal. To estimate supply and demand functions simultaneously, the data must include prices and quantities for the good in question, plus exogenous variables related to both supply and demand shifts. For the model discussed above, the demand for charcoal is determined by the price of coal. Short-term shifts in the demand for plantation-origin charcoal may depend on transportation costs and the supply of

native-origin charcoal. The area of mature eucalyptus available for harvest provides a supply-shifter for plantation-origin charcoal, but no such shifter was available for native-origin charcoal.

Thus, the following equations were used to estimate the supply and demand functions for plantation-origin charcoal:

$$\text{Demand: } P_{Ch} = \beta_0 - \beta_1 Q_{ChPl} + \beta_2 P_{CoI} + \beta_3 P_{CoN} + \beta_4 P_{Tr} + \beta_5 Y + e_D \quad (3)$$

$$\text{Supply: } Q_{ChPl} = \theta_0 + \theta_1 P_{Ch} + \theta_2 Plant_{t-8} + e_S \quad (4)$$

where: Q_{ChPl} is the quantity of plantation-origin charcoal in Minas Gerais;

P_{Tr} is the real price of diesel in Brazil;

Y is the national income;

$Plant_{t-8}$ is the area of eucalyptus planted eight years before, except areas planted by the pulp and paper industry (in hectares);

P_{Ch} is the real price of charcoal;

P_{CoI} is the real price of imported coal;

P_{CoN} is the real price of national coal;

and e_D and e_S are error terms.

The price of diesel is assumed to be a major factor in the transport cost of native-origin charcoal. National income was included to try to capture the effects of Brazilian business cycles on the demand function. The area planted eight years before was used to estimate the quantity

of mature eucalyptus available. Plantings by the pulp and paper industry were subtracted from total plantings under the assumption that all eucalyptus not used for pulp was used for charcoal (see Table 1). A lag of eight years was used on plantings since that is the average rotation age.

An investment model of the planting decision for eucalyptus was also estimated. The planting stage is where the fiscal incentives are most likely to influence the charcoal market. This model measures the effect on planting levels of the subsidy program limits on the percentage of taxes that can be used for tax credits and indicates what area might have been planted without the incentives--i.e., zero percent of taxes eligible for tax credits. Although the data are only for the period when the subsidy was available, a range of tax credit limits from 50% to 17.5% were used, allowing a provisional extrapolation to no incentive.

I used an investment decision model similar to those used by de Steiguer (1983) and Brooks (1985) to model the planting decision. De Steiguer modeled non-incentive investments in forestry by private non-industrial forest owners in the south-east U.S. His model included the level of expenditures for cost-share assistance for that year, expected sawtimber stumpage prices, personal income, and real interest rate expectations as explanatory variables. He found that expected stumpage prices and cost-share

expenditures had no influence on producers' private investment levels, but that personal income and expected interest rates had a measurable effect.

Brooks modeled total private non-industrial forest planting in the south-east U.S. as a function of cost-share expenditures, expected stumpage revenues, and planting costs. He found that the area planted in response to government cost-share expenditures was greater than the total area planted under the incentives programs. Brooks attributes this result to positive, indirect effects of incentives programs, such as: (1) the advertising effect of the programs, and (2) increased confidence in the merits of forest management due to government sponsorship.

My model is different than de Steiguer and Brooks' models in that an incentive limit was used rather than incentive expenditures. When the area planted is the dependent variable, program expenditures may not be exogenous. An incentive limit--such as the percentage of taxes due eligible for tax credits--is exogenous and is probably a superior measure of the marginal effect of the program on participants' decisions. I also expected factors such as the expected prices of charcoal, coal, and transportation to affect planting rates. Since I had no obvious model for expected prices, current prices were used; thus the model:

$$Plant_t = \delta_0 + \delta_1 I_t + \delta_2 P_{Ch,t} + \delta_3 P_{Ch,t} * I_t + \delta_4 P_{CoI,t} + \delta_5 P_{CoN,t} + \delta_6 P_{Tr,t} + e_t \quad (5)$$

where: $Plant_t$ is the area of eucalyptus planted (in hectares) in time t;

I_t is the incentive limit in time t;

$P_{Ch,t}$ is the real price of charcoal in time t;

$P_{Ch,t} * I_t$ is an interaction term between the incentive limit and the charcoal price;

$P_{CoI,t}$ is the real price of imported metallurgical coal in time t;

$P_{CoN,t}$ is the real price of national coal in time t;

$P_{Tr,t}$ is the real price of diesel in time t;

and e_t is an error term;

An interaction term between the incentive limit and the price of charcoal was included to test the hypothesis that high incentives would reduce the effect of prices on the decision to plant. Morzuch et al (1980) found that in the United States, wheat acreage supply responses to prices varied with the level of government policy intervention. They divided their data set into two periods--one with a high level of government intervention, the other with a low level--and estimated the supply response for each period separately. I did not use this approach in my study because of the limited degrees of freedom available. The interaction term allowed measuring the same kind of slope shift at the cost of only one degree of freedom.

The best way to interpret the interaction term is to take the derivative of the planting decision model with respect to the price of charcoal and to the incentive limit. These derivatives are:

$$\frac{d\ Plant_t}{d\ P_{Ch,t}} = \delta_2 + \delta_3(I_t)$$

$$\frac{d\ Plant_t}{d\ I_t} = \delta_1 + \delta_3(P_{Ch,t})$$

With this form of equation, the planting decision is still a linear function of either prices or the incentive limit. However, the slopes of these functions change when the other variable changes. In other words, for a given incentive limit, the change in planting for a change in prices is fixed and linear; this response changes if the incentive limit changes, but remains linear.

Figure 3 illustrates an example where an interaction between the price effect and the incentives effect exists. In this example, the government reimburses producers' costs completely up to some planting level. Thus each producer's individual supply curve is a vertical line at the subsidized quantity and equals that producer's marginal cost curve for quantities above the subsidized limit.

Two things can happen in this case: (1) if the price line intersects the producer's marginal cost curve at a quantity less than the subsidized amount, the producer will

Total units produced for each price-incentive combination.

	P_1	P_2	P_3	P_4
I_0	3	6	9	12
I_1	4	6	9	12
I_2	6	7	9	12
I_3	9	9	10	12
I_4	12	12	12	13

Change in total units produced as prices change, for each incentive level.

	P_1-P_2	P_2-P_3	P_3-P_4
I_0	3	3	3
I_1	2	3	3
I_2	1	2	3
I_3	0	1	2
I_4	0	0	1

Change in total units produced as incentives change, for each price level.

	I_0-I_1	I_1-I_2	I_2-I_3	I_3-I_4
P_1	1	2	3	3
P_2	0	1	2	3
P_3	0	0	1	2
P_4	0	0	0	1

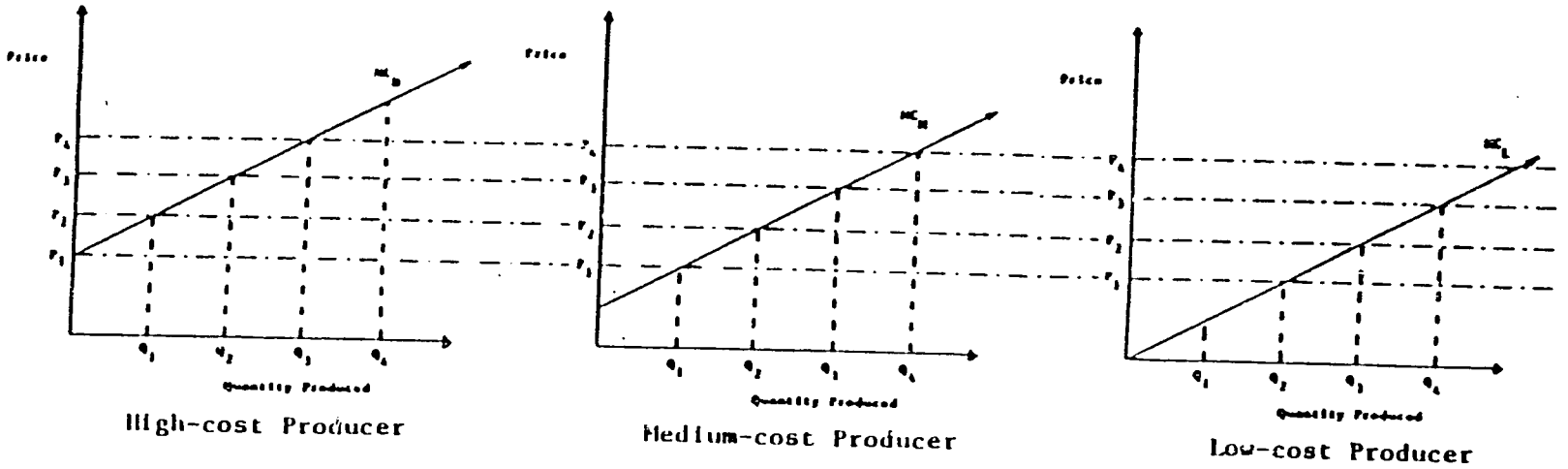

Figure 3. Model illustrating interaction effects between product prices and incentive limits on marginal planting decisions.

plant the amount subsidized; (2) if the price line intersects his marginal cost curve at a quantity greater than the subsidized amount, the producer will plant the quantity where this intersection occurs, and the subsidy will have no effect on that producer's marginal planting decision.

In this case, when prices are low, a given incentive limit will have a greater marginal effect on planting than when prices are high. This is because at high prices, more producers will be planting more than the subsidy limit and thus will not be affected by the subsidy at the margin. At low prices, an increasing proportion of producers will be affected by the incentive limit as they reduce their output.

Similarly, when the incentive limits are low, most producers consider only marginal costs and product prices at the margin and price responses will be high. When the incentive limits are high, many producers' production levels are determined by the incentive level and production will be unresponsive to product prices.

In Figure 3, three producers' cost curves are shown. The first table shows total production for each price-incentive combination. I_0 is the case where no incentive is available. I_1 - I_4 correspond to subsidy limits equal to Q_1 - Q_4. The second and third tables give the marginal change in production for price shifts and

incentives shifts, respectively. Units in all three tables correspond to $Q_1 = 1$, $Q_2 = 2$, and so on.

With no incentive, an increase in prices induces each producer to produce one more unit--a total increase of 3 units. However, as the incentive limits are raised, the marginal effects of price shifts become less and less: at I_4, price shifts from P_1 to P_2 or P_2 to P_3 have no effect on production. Similarly, at low prices, increases in the incentive limits induce production increases. However, at high prices, only the highest subsidy limit has any effect on production.

In Figure 3, at any given level of the incentive, the marginal effect of price shifts is not constant, and at any given price level, the marginal effect of incentive limit shifts is not constant. This suggests that the model above should include quadratic terms for the price and incentive limit effects. However, testing for this possibility was not considered important enough to justify utilizing two more degrees of freedom. The important point illustrated in Figure 3 is the possibility of a negative interaction between price and incentive level effects.

In summary, economic theory suggests that both derivatives given above will be positive--i.e., planting levels should respond positively to price or subsidy increases. However, the example above indicates that the interaction coefficient may be negative when a subsidy with

quantity limits is used. The quantity limits in the Brazilian forestation incentives program are the limits on the percentage of taxes that can be used for tax credits.

V. Statistical Results and Discussion [5]

The two-stage least squares estimates of the plantation-origin charcoal supply and demand parameters are shown in Table 4 and Table 5. With two-stage least squares, the parameter estimates are asymptotically unbiased. However, asymptotic properties may not be relevant in this case, where only ten observations are used. Regarding the small sample properties of two-stage least squares (2SLS) versus ordinary least squares (OLS) Kmenta (1971) states:

> "Monte Carlo studies indicate that OLS estimates tend to have a larger bias but a smaller variance than 2SLS. If mean square error is used as a criterion in comparing [these] estimators the results are somewhat mixed. In some cases, the OLS estimator performs better than 2SLS, in others worse, in others about the same. . . At least from the point of view of hypothesis testing or interval estimation, the OLS method is inferior to [2SLS]." (pp. 584-585)

The results of the full model are clearly not statistically significant. This is the result of very strong multicollinearity between the independent variables of the model. The elimination of any one of the variables

5. Statistical estimation of the three models described in the previous section was carried out with the SAS computer software system. PROC SYSREG, the procedure used, is described in SAS (1982).

decreased this problem somewhat, so parameters were estimated for the model with each variable removed. The model with the price of diesel removed gave the best fit, as measured by the R-squared and F statistics. The coefficient of Q_{Ch} ($\hat{\beta}_1$) in this model is also significant at the .05 level.

None of the F-statistics for the demand models is statistically significant, so only provisional conclusions can be drawn from these results. The demand price elasticity implied by two of these models is positive. However, the implied price elasticity is inversely related to $\hat{\beta}_1$, and a coefficient equal to zero indicates an infinitely elastic demand. For both cases where $\hat{\beta}_1$ is positive, the associated standard errors are very large, thus the estimates are not statistically different from zero. Overall, the results suggest that the demand for plantation-origin charcoal is fairly elastic. The results given in Amancio _et al_ (1983) also support this conclusion. They estimated a demand price elasticity for charcoal in Minas Gerais of -7.1.

The F-tests for the supply equations, on the other hand, are all significant at the .05 level. Also, the R-squared statistics are generally acceptable. The negative coefficients on the price of charcoal are not consistent with economic theory, but the standard errors on these estimates are very large, indicating a supply price

Table 4. Two-Stage Least Squares Estimation of the Demand Function (1974-1983).

Demand Estimation: $P_{Ch} = \beta_0 + \beta_1 Q_{Ch} + \beta_2 P_{Col} + \beta_3 P_{CoN} + \beta_4 P_{Tr} + \beta_5 Y$

Parameter:	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	R^2	F	DW	D
Full Model	-32,427	-3.25	5.41	-9.14	2,222	1.15	.060	0.04	2.79	-0.09
	(215,413)	(20.89)	(34.81)	(59.68)	(14,908)	(6.97)				
w/o P_{Col}	1,567	0.08	----	0.25	-145	0.04	.486	0.94	3.04	3.67
	(1,352)	(0.19)		(0.31)	(123)	(0.10)				
w/o P_{CoN}	319	-0.08	0.07	----	-46	0.10	.621	1.64	2.64	-3.67
	(913)	(0.08)	(0.12)		(50)	(0.07)				
w/o P_{Tr}	-417	-0.15*	0.23	-0.26	----	0.13	.630	2.13	3.06	-1.96
	(765)	(0.05)	(0.16)	(0.17)		(0.07)				
w/o Y	2,759	0.15	-0.26	0.57	-197	----	.414	0.71	2.93	1.96
	(2,372)	(0.26)	(0.50)	(0.80)	(224)					

(Standard errors of estimates are given in parentheses.)
($F_{.05,5,4} = 6.26$; $F_{.05,4,5} = 5.19$)
($DW_{.05,K=5,15} = 1.79-3.44$; $DW_{.05,K=4,15} = 2.03-3.31$)
* Significant at the .05 level.

Table 5. Two-Stage Least Squares Estimation of the Supply Function (1974-1983).

Supply Estimation: $Q_{ChPl} = \theta_0 + \theta_1 P_{Ch} + \theta_2 Plant_{t-8}$

Parameter:	$\hat{\theta}_0$	$\hat{\theta}_1$	$\hat{\theta}_2$	R^2	F	DW	S
Full Model	2681	-1.75	0.020*	.737	8.24*	1.56	-0.51
	(2480)	(2.60)	(0.008)				
w/o P_{Col}	1792	-0.80	0.022*	.725	7.91*	1.67	-0.24
	(2708)	(2.85)	(0.008)				
w/o P_{CoN}	3587	-2.72	0.019	.734	8.30*	1.34	-0.81
	(2629)	(2.76)	(0.008)				
w/o P_{Tr}	3064	-2.16	0.020*	.738	8.45*	2.10	-0.63
	(2532)	(2.66)	(0.008)				
w/o Y	4497	-3.69	0.017	.711	7.40*	2.10	-1.08
	(3458)	(3.65)	(0.009)				

(Standard errors of estimates are given in parentheses.)
($F_{.05,2,7} = 4.74$)
($DW_{.05,K=2,15} = .95-1.54$)
* Significant at the .05 level.

elasticity not statistically different from zero. Again, these results are consistent with Amancio et al (1983) who estimated a charcoal supply price elasticity of 0.05.

The coefficients on the lagged planting variable are all significant at the .10 level. This indicates that the supply of plantation-origin charcoal is determined mostly by the amount of mature standing timber that is available. This result suggests that there is a direct link between the planting decision and the supply of plantation-origin charcoal eight years later.

Durbin-Watson statistics were calculated for all the supply and demand models to test for first-order autocorrelation. Critical ranges are given for this statistic at the bottom of each table. When the Durbin-Watson statistic is above 2 and greater than the high number in the critical range, statistically significant evidence of autocorrelation exists. When the statistic is within the critical range, the test is inconclusive. Finally, if the statistic is less than the low value of the critical range, but greater than 2, there is no evidence of autocorrelation. Alternatively, when the statistic is less than 2, a value below the critical range indicates autocorrelation, a value within the range is inconclusive, and a value above the range indicates that no autocorrelation exists (Kmenta, 1971, pp. 295-297).

For the demand models, the Durbin-Watson statistic is consistently inside the questionable zone. Therefore, accounting for possible autocorrelation in these models might improve the accuracy of the results by reducing estimator variances. However, autocorrelation does not bias the results as calculated,[6] so no attempt was made to correct this factor. All but one of the supply models showed no evidence of autocorrelation.

The least squares estimates for the planting decision model are given in Table 6. The variables for the price of native and imported coal and the price of diesel have very little explanatory power, so they were dropped from the analysis, leaving Reduced Model A. Reduced Model B shows the effect of dropping the interaction term as well. Durbin-Watson statistics were also calculated for these models. Two of these tests were only marginally in the critical zone where the test is inconclusive, and the other indicates no evidence of autocorrelation, so I concluded that autocorrelation was not a problem.

Except for the full model, the F-tests for the planting models are all significant at the .05 level--most much more than that. Yet, the t-tests for the individual parameters in the unrestricted models are not significant. This is because of multicollinearity between the primary variables:

6. See Kmenta (1971) pp. 273-282 for a discussion of the properties of 2SLS estimators when autocorrelation exists.

Table 6. Ordinary Least Squares Estimation of the Planting Decision Model (1968-1985).

Planting Decision Model: $Plant_t = \delta_0 + \delta_1 I_t + \delta_2 P_{Ch,t} + \delta_3 (I_t * P_{Ch,t}) + \delta_4 P_{Col,t} + \delta_5 P_{Cow,t} + \delta_6 P_{Tr,t}$

Parameter:	$\hat{\delta}_0$	$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{\delta}_3$	$\hat{\delta}_4$	$\hat{\delta}_5$	$\hat{\delta}_6$	R^2	F	DW
Full Model:	-125,710	3,752	369	-10.5	-15.8	31.8	138	.702	3.93	1.63
	(209,174)	(7,470)	(223)	(10.5)	(28.7)	(35.3)	(4860)			
Restricted Full:	-79,587	1,389	300**	-7.0	-16.2	31.4	413	.699	5.11**	---
(δ_3=-7)	(149,294)	(2,064)	(76)	(N.A.)	(27.5)	(33.8)	(4591)			
Restricted Full:	-53,012	28	261**	-5.0	-16.4	31.2	571	.694	4.99**	---
(δ_3=-5)	(150,485)	(2,080)	(77)	(N.A.)	(27.7)	(34.0)	(4627)			
Reduced Model A:	-95,886	4,650	364	-10.8	----	----	----	.674	8.95**	1.78
	(149,221)	(6,705)	(204)	(9.5)						
Restricted A:	-41,630	1,988*	287**	-7.0	----	----	----	.670	14.20**	---
(δ_3=-7)	(60,035)	(762)	(66)	(N.A.)						
Restricted A:	-13,009	585	247**	-5.0	----	----	----	.664	13.86**	---
(δ_3=-5)	(60,519)	(768)	(67)	(N.A.)						
Reduced Model B:	58,544	-2,925**	146	----	----	----	----	.641	12.52**	1.49
	(62,569)	(794)	(69)							

(Standard errors of estimates are given in parentheses.)
* Significant at the .05 level.
** Significant at the .01 level.
($F_{.05,6,11}$=3.09; $F_{.05,5,12}$=3.11; $F_{.05,3,14}$=3.18; $F_{.05,2,15}$=3.68)
($DW_{.05,K=5,18}$ = .71-2.06; $DW_{.05,K=3,18}$ = .93-1.69; $DW_{.05,K=2,18}$ = 1.05-1.53)

the incentive level, charcoal prices, and the interaction term. By fixing one of these coefficients at a reasonable level, this problem can be largely avoided.

The interaction coefficient is the logical one to fix because it is, of course, highly correlated with the incentive level and the charcoal price. The estimated interaction coefficient is so large, that at the maximum level of the subsidy (50% of taxes due) the planting decision becomes negatively related to price, and at all price levels experienced, the planting decision is negatively related to the incentives. By fixing this coefficient at -5, the price effect is approximately zero at the maximum level of the incentive. Table 4 also shows the result of setting the restriction at -7. When δ_3 is restricted, the standard errors of the estimates of δ_1 and δ_2 become much smaller, as expected.

As previously discussed, the derivatives of the planting decision model with respect to the price of charcoal and the incentive limit are:

$$\frac{d\ Plant_t}{d\ P_{Ch,t}} = \delta_2 + \delta_3(I_t)$$

$$\frac{d\ Plant_t}{d\ I_t} = \delta_1 + \delta_3(P_{Ch,t})$$

Thus, for reduced model A, with δ_3 restricted at -5, the change in hectares planted for a one cruzeiro change in the

price of charcoal is estimated to be 247 - 5(I_t). This means that when the incentive limit is 50%, -3 hectares are planted for a one cruzeiro increase in the price of charcoal; when the incentive limit is 17.5%, 159.5 additional hectares are planted for each one cruzeiro increase in the price of charcoal.

The change in hectares planted for a one percent change in the incentive limit--as estimated for reduced model A with δ_3 restricted at -5 --is 585 - 5($P_{Ch,t}$). The average real price of charcoal during the study period was 774 cruzeiros. At this price, a one percentage point increase in the portion of taxes eligible for reforestation tax credits will decrease the area planted by 3,285 hectares. Thus, the results of this study show that the area planted increased as the subsidy limits decreased. This is basically the result obtained for reduced model B where no interaction was included and the coefficient on the incentive limit variable is -2.925. Note that not including the interaction term is the same as restricting the interaction term at zero. Thus it is not possible to make the incentive response positive by restricting δ_3.

VI. Summary and Implications

The Brazilian fiscal incentives for forestry were instituted in 1967 with the goal of increasing the area of industrial plantations. Thus, cutting pressure would be reduced for natural forests and industries would still be assured of having an adequate resource base. The results of this study, however, indicate that the actual effect of the incentives may have been to reduce the amount of planting.

A conclusion that planting levels were negatively related to the subsidy limit is difficult to accept. A better explanation may be that the limit as measured in this study--percentage of taxes due eligible for tax credits--was not the true limiting factor for the subsidy program. Perhaps the true limits were determined by was the resources available for administering the program. For example, the number of projects approved may have been limited by the number that could be inspected. Another limiting factor might have been an informal budgeting system for the subsidy program, where the number of projects approved was restricted to limit the forgone revenue to the treasury. No record of specific budget limits or of formal criteria for allocating limited funds was found.

Corporations' abilities to react to the incentives quickly may also have limited the rate of growth in the planting programs. It takes time to acquire the necessary

trained personnel to manage planting programs. Nurseries to produce seedlings also have to be established. Many corporations, however, planted large areas without incentives. These companies, at least, were not constrained by production capacity in their ability to use the subsidies.

Perhaps the observed planting pattern over time is best explained by other economic factors not included in this study. The real rate of interest, the availability of investment funds for the private sector, inflation, and the rates of return in alternative investments could all be important factors. All of these factors, except inflation, are difficult to observe for Brazil. Interest rates are observable in theory, but rates are extremely variable, depending on the lender and the borrower. It is difficult to make sense of the effect of inflation without more information on the other factors.

It seems a safe conclusion, at least, that the limits on the percent of taxes eligible for forestation tax credits were not an important factor affecting the planting rate of eucalyptus in Minas Gerais. Charcoal prices appear to have had the expected positive effect. The interaction term was also negative as expected, but it is doubtful that this term has much meaning, given the questionable influence of the subsidy limits on planting levels.

I was unable to accurately estimate the demand function for plantation-origin charcoal in this study. However, theoretical considerations, a previous study (Amancio *et al.* 1983), and the provisional results obtained in this study all indicate that the demand for charcoal is price elastic. The supply of plantation-origin charcoal, on the other hand, is evidently very price inelastic. The quantity supplied is determined mostly by the amount of mature eucalyptus available--i.e., by past planting decisions. This also means that harvesting decisions are not affected much by charcoal price shifts. Thus, any effects the subsidy program had on the planting decision directly affected the supply of plantation-origin charcoal eight years later.

In summary, the results for the planting decision model suggest that the percentage of taxes eligible for forestation tax credits did not influence planting rates. Planting rates do appear to be responsive to current charcoal prices. While the model of the charcoal market in Brazil has not been definitely verified by the results of the statistical analysis, the results are consistent with the general concepts of the hypothesized model.

BIBLIOGRAPHY

ABRACAVE: Brazilian Association of Charcoal Producers, Belo Horizonte, Brazil. Private communication.

Amancio, Maria Rita de Cassia, Sergio Alberto Brandt, and Aloissio Rodrigues Pereira. 1983. Modelo Recursivo da oferta e demanda de carvao vegetal para siderurgia no Estado de Minas Gerais. Brazil Florestal. 56:31-36.

Brooks, David J. 1985. Public Policy and Long-term Timber Supply in the South. Forest Sci 31(2):342-357.

Beattie, W. D., 1975. An Economic Analysis of the Brazilian Fiscal Incentives for Reforestation. Unpublished Phd. Dissertation, Purdue Univ. 301 p. Mimeographed.

Beattie, W. D., and Joldes M. Fierra, 1979. Analise Financeira e Socio-Economica do Reflorestamento no Brasil. IBDF-COPLAN Serie: Estudos Perspectivos para o Periodo 1979-1985. Brasilia, Brasil.

Berger, R., 1980. The Brazilian Fiscal Incentives Act's Influence on Reforestation Activity in Sao Paulo State. Unpublished Phd. Dissertation, Michigan State Univ., East Lansing. 81 p. Mimeographed.

CENIBRA: A Division of the Companhia do Rio Vale Doce, Belo Horizonte, Brazil. Private communication.

CNP: National Petroleum Council, Brasilia, Brazil. Personal Communication.

de Steiguer, J. E., 1983. The Influence of Incentive Programs on Nonindustrial Private Forestry Investment. In Royer and Risbrudt. 1983. Nonindustrial Private Forests: A Review of Economic and Policy Studies. pp. 157-163.

Fisher, Anthony C. 1981. Resource and Environmental Economics. Cambridge University Press. 284p.

Gregersen, Hans M. and Stephen E. McGaughey, 1985. Improving Policies and Financing Mechanisms for Forestry Development. Inter-American Development Bank. 105p.

Hirschleifer, Jack, 1984. Price Theory and Applications. 3rd Ed. Frentice Hall, Inc. 573 p.

IBDF: Brazilian Institute of Forest Research, Belo Horizonte, Brazil. Private Communication.

Kmenta, Jan, 1971. Elements of Econometrics. Macmillan Publishing Co., Inc. New York, NY. 655 p.

Matt, V. A., 1973. Analysis of Timber Supply: Minas Gerais, Brazil. Unpublished Phd Dissertation, State University of N.Y.

Morzuch, B., R. Weaver, and P. Helmberger. 1980. Wheat acreage supply response under changing farm programs. Am. J. Agric. Econ. 62:29-37.

Pereira, Luiz Bresser. 1984Development and Crisis in Brazil, 1930-1983. Trans. Marcia Van Dyke. Westview Press, Inc. Boulder, CO. 241p.

Royer, Jack P., and Christopher D. Risbrudt, 1983. Nonindustrial Private Forests: A Review of Economic and Policy Studies. Symposium Proceedings sponsored by Duke University, School of Forestry and Environmental Studies; Durham, North Carolina. 398 p.

SAS Institute, 1982. SAS/ETS Users Guide: Econometric Time Series Library. SAS Institute (Statistical Analysis System). Cary, NC. 398 p.

SIDERBRAS: Brazilian National Steel Company, Brasilia, Brazil. Private Communication.

Syvrud, Donald E. 1974. Foundations of Brazilian Economic Growth. Hoover Institution Press, Stanford University, Stanford, CA. 295p.

Westoby, Jack C., 1962. Forest Industries in the Attack on Underdevelopment. Unasylva. April, 1962. pp. 68-101.

APPENDIX: Data

Accessing Brazilian data from the United States is understandably difficult. The difficulty is not so much due to the lack of well-kept statistics for Brazil; although not as well-kept as United States statistics, for the most part, records do exist and are reasonably accurate. The problem is mostly one of accessing these records. Therefore, I have included this appendix containing my data sets for future reference.

What success I did have in obtaining data was due to the use of the telephone in making contact with potentially helpful Brazilian officials and bureaucrats. I was aided by Marcos Santana, a Brazilian graduate student at NCSU, who translated for me and provided invaluable experience with the Brazilian system. Over the telephone, we were able to reach the persons closest to the particular information we were seeking. If the organization did not have the data we were looking for, they could at least help us find out where we might try next. In our case, much of the information was transferred directly over the telephone. However, the primary advantage of using the telephone was in finding out who had the data we were interested in and who was willing to help.

Where necessary, some values were estimated. This appendix also describes the procedures used to estimate these values.

Data on areas planted in Minas Gerais by species and by source of funds--incentive laws 5106, 1134, or private--for each year were obtained from the IBDF (Table A1 and Table A2). Table A3 gives the percentage of taxes due eligible for tax credits for each year and the Brazilian government's expenditures on forestry incentives in Minas Gerais. The IBDF also provided harvest data for Minas Gerais for each year since 1974 for eucalyptus (Table A4) and since 1975 for pine (Table A5). The harvest data included information on area harvested, trees per hectare, yields, and average annual increment.

Data on areas planted and harvested for pulp and paper were obtained from CENIBRA, the only pulp and paper company in Minas Gerais (Table A6). It was assumed that all eucalyptus not utilized for pulp and paper was converted to charcoal.

ABRACAVE (the Brazilian Association of Charcoal Producers) provided data on the amount of charcoal produced in Brazil from native forests and from plantations (Table A7). Data on charcoal consumption by the iron and steel industries in Brazil and Minas Gerais were also included. For most years, recorded consumption of charcoal in Minas Gerais is exactly 90% of Brazilian consumption. Based on this, it was assumed that 90% of each type of charcoal was also produced in Minas Gerais. Charcoal exports were also reported by ABRACAVE (Table A8).

ABRACAVE also provided annual data on the price of charcoal in Minas Gerais since 1975 (Table A9). Data for 1982-1986 were reported in detail: by month and planning region within Minas Gerais (Tables A10-A14). Where charcoal prices were needed for dates before 1975, some values were calculated from a cost index for charcoal given in Beattie (1975, p.225). Beattie notes that the index value for 1974 is based on a real (1973) price for charcoal of Cr$ 57.00. This translates to a nominal price of Cr$ 74.01, thus all other index numbers were divided by (2701/74.01) to obtain nominal prices for charcoal in those years.

Finally, ABRACAVE provided information on annual production levels--with charcoal and with coal--of steel (Table A14), pig iron (Table A16), and iron alloys (Table A17). Also included were annual charcoal consumption levels in the production of each of these products. Tables A18 and A19 give export data for pig iron and iron alloys. No export information was given for steel. Other information from ABRACAVE included the consumption of charcoal in cement-making in Brazil (Table A20) and in the production of other primary metals (Table A21).

SIDERBRAS is a public/private company that has handled all the coal imports for the iron and steel industry since 1979. They provided price series for national and imported metallurgical coal for 1979-1985. Since this time series was not long enough for this analysis, values for the price

of imported coal for 1967-1971 were calculated from the cost index for coal in Beattie (1985, p.225). The method used was the same as described above for charcoal (based on an assumed 1974 price of coal of Cr$ 425 per ton). Coal prices for 1972-1978 were then estimated by regressing these data on Brazilian prices in constant US$ versus U.S. coal (bituminous) prices in constant US$. The results of this regression were;

$$P_{BrCo} = \underset{(16.1)}{46.3} + \underset{(.75)}{1.73}\, P_{USCo} \qquad \text{R-squared: } .322$$

Although the R-squared statistic is not high for this model, the t-ratios for each coefficient and the F-statistic for the model were significant at the .05 level. The export price of U.S. coal (bituminous, FOB at an eastern Port) was found in the Department of Energy 1985 Annual Report to the Congress. The import price of coal and estimated values are listed in Table A9 with the charcoal prices.

SIDERBRAS also provided data on the price of national metallurgical coal for the period 1979-1985. In an attempt to extend this price series to earlier dates, I tried to find another source for such prices. The Brazilian National Council of Petroleum (CNP) provided data on the prices of coal used for energy, originating from the states of Parana, Santa Catarina, and Rio Grande du Sul. The CNP also

provided price series for diesel in Brazil. The price of diesel is regulated by the Brazilian government, and is the same throughout the country. These price series are listed in Table A22.

Exchange rates for dollars and cruzeiros and Brazilian and U.S. producer price indexes were obtained from the International Monetary Fund Yearbook for 1985 and Monthly Report for February 1986. National Income and Gross Domestic Product time series for Brazil were also obtained from this source. National Income data were not given for the period 1982-1984, so estimates were used based on regressing real (1980) National Income on real (1980) Gross Domestic Product and using the resulting predicted values for those years. The results for this regression were:

$$INC = \underset{(370)}{-1475} + \underset{(0.040)}{1.046}\ GDP \qquad R\text{-squared: } .980$$

Based on the close fit and low standard errors for this regression, it is safe to conclude that the estimated National Income values are reliable. These data can be found in Table A23.

Table A1. Hectares of Eucalyptus Planted With and Without Tax Incentives in Minas Gerais.

Year	Eucalyptus Planted With Incentives	Eucalyptus Planted with Private Resources	Total Area of Eucalyptus Planted
1967	4,859	---	4,859
1968	13,815	---	13,815
1969	21,079	15,189	36,268
1970	35,592	5,800	41,393
1971	36,067	49,970	86,037
1972	48,658	8,576	57,234
1973	44,582	6,428	51,010
1974	69,840	8,180	78,020
1975	114,774	7,588	122,362
1976	130,050	28,792	158,842
1977	142,888	35,843	178,731
1978	152,665	31,506	184,171
1979	164,428	36,173	200,601
1980	125,318	34,236	159,554
1981	102,409	20,528	122,937
1982	114,505	11,859	122,364
1983	57,109	15,945	73,054
1984	80,461	7,820	88,821
1985	83,447	7,984	91,431

Table A2. Hectares of Pine and Fruit Trees Planted With and Without Tax Incentives in Minas Gerais.

Year	Pine Planted With Incentives	Pine Planted with Private Resources	Total Area of of Pine Planted	Fruit Trees Planted with Incentives	Area of All Species Planted With Incentives
1967	----	----	----	----	4,859
1968	----	----	----	----	13,815
1969	----	----	----	----	21,079
1970	----	161	161	----	35,592
1971	8,309	450	8,759	4,446	48,821
1972	7,680	----	7,680	942	57,279
1973	11,237	327	11,564	3,222	59,041
1974	7,439	35	7,474	1,706	78,985
1975	22,496	176	22,672	1,020	138,289
1976	27,870	68	27,938	1,650	159,571
1977	24,612	----	24,612	3,444	170,944
1978	30,710	----	30,710	2,000	185,375
1979	28,500	8	28,508	1,200	194,128
1980	18,419	----	18,419	100	143,837
1981	8,547	150	8,697	----	110,956
1982	9,600	9,600	9,600	----	124,105
1983	2,152	----	2,153	----	59,261
1984	4,308	----	4,308	----	84,770
1985	2,144	----	2,144	----	85,591

Table A3. Percentage of Taxes Due Eligible for Tax Credits and Total Expenditures on Forestry Incentives in Minas Gerais.

Year	Percentage of Taxes Due Elligible for Tax Credit	Total Expenditures on Forestry Incentives (OTN)[1]
1967	50.0	----
1968	50.0	----
1969	50.0	----
1970	35.0	----
1971	30.0	----
1972	25.0	----
1973	25.0	----
1974	22.5	3,438,821
1975	20.0	6,836,631
1976	17.5	8,266,619
1977	17.5	8,613,543
1978	17.5	9,636,330
1979	17.5	10,839,318
1980	17.5	11,975,532
1981	17.5	8,562,329
1982	17.5	8,892,284
1983	17.5	4,503,308
1984	17.5	4,916,983
1985	17.5	6,710,152

[1] OTN are a form of government bond, bearing interest and partially corrected for inflation.

Table A4. Eucalyptus harvest data for Minas Gerais.

Year	Area Harvested (Hectares)	Average No. Trees per Hectare	Average Volume (m^3/ha.)	Average Volume (Steres/ha.)	Average Ann. Increment (Steres/ha./yr.)	Average age at Harvest
1976	12,144	1,780	137.00	194.84	22.60	8.6
1977	12,851	1,605	143.24	205.10	24.10	8.5
1978	39,935	1,510	115.90	168.77	20.02	8.4
1979	41,328	1,324	97.30	145.95	20.85	7.0
1980	89,405	1,383	95.91	143.71	20.72	6.9
1981	79,428	1,326	99.96	149.94	18.23	8.2
1982	67,830	1,450	114.05	171.08	19.73	8.7
1983	105,952	1,236	89.15	133.73	16.90	7.9
1984	153,505	1,163	66.04	99.06	15.68	6.3
1985	171,583	1,254	78.19	117.29	15.83	7.4

Table A5. Pine harvest data for Minas Gerais.

Year	Area Harvested (Hectares)	Average No. Trees per Hectare	Average Volume (m^3/ha.)	Average Volume (Steres/ha.)	Average Ann. Increment (Steres/ha./yr.)	Average age at Harvest
1977	792	2,099	168.45	245.08	28.83	8.5
1978	252	1,252	64.13	96.20	13.74	7.0
1979	3,971	1,573	95.13	142.88	17.86	8.0
1980	3,693	1,798	175.40	262.34	25.71	10.2
1981	2,014	1,830	276.13	414.20	43.50	9.5
1982	1,856	1,086	111.83	167.75	19.62	8.5
1983	5,893	1,215	210.74	316.11	36.82	8.6
1984	7,646	1,708	282.51	423.77	37.37	11.3
1985	8,979	935	86.64	129.96	29.27	4.4

Table A6. Planting and Harvesting of Eucalyptus for Pulp and Paper. (Hectares)

Year	Eucalyptus Planted	Pine Planted	Eucalyptus Harvested
1967	0	0	0
1968	0	2,902	0
1969	0	0	0
1970	0	0	0
1971	2,619	31	0
1972	4,265	97	0
1973	1,260	108	0
1974	4,188	1,049	0
1975	7,410	445	0
1976	19,489	3,262	0
1977	10,985	10,679	5,000
1978	7,958	3,962	5,000
1979	6,234	111	5,000
1980	9,196	0	5,000
1981	9,324	0	5,000
1982	6,196	0	5,000
1983	4,250	0	5,000
1984	2,460	2,107	5,000
1985	2,261	2,000	5,000
1986	3,022	1,500	----

Table A7. Brazilian Charcoal Production and Consumption in Metallurgy.
(All Units are m^3)

Year	Native-Origin Charcoal Production	Plantation-Origin Charcoal Production	Total Charcoal Production	Consumption of Charcoal in Metallurgy (Brazil)	Consumption of Charcoal in Metallurgy (Minas Gerais)
1974	---	---	---	11,477,287	10,329,558
1975	---	---	---	13,715,369	12,343,832
1976	14,044,136	1,455,864	15,500,000	14,486,038	13,037,434
1977	13,648,140	1,601,860	15,250,000	14,313,021	12,881,719
1978	13,317,352	1,832,648	15,150,000	14,229,511	12,806,560
1979	15,116,033	2,183,967	17,300,000	16,704,983	15,034,485
1980	16,866,499	2,777,501	19,644,000	18,541,527	16,687,374
1981	15,576,651	3,653,782	19,230,433	17,494,357	15,744.921
1982	14,928,612	3,732,153	18,660,765	16,458,397	14,812,557
1983	18,422,967	4,086,928	22,509,895	19,348,183	16,445,956
1984	24,597,266	5,009,797	29,607,063	25,157,424	21,158,872

Table A8. Brazilian Charcoal Exports.

Year	Metric Tons Exported	Value US$ FOB
1979	31,169	2,149,663
1980	25,428	1,539,867
1981	9,435	1,010,105
1982	3,169	500,466
1983	6,512	774,080
1984	10,980	1,214,639

Table A9. Relative Prices for Charcoal and Imported Coal in Minas Gerais.

Year	Real Price of Charcoal (1980 $CR) ($m^3$)	Price of Imported Coal (cif) (1980 $CR) (ton)
1968	629.16*	2990.34*
1969	720.63*	3531.66*
1970	853.32*	3422.21*
1971	708.41*	4023.80*
1972	604.16*	3545.99*
1973	-	3290.28+
1974	850.57	4886.63+
1975	756.76	4552.73+
1976	886.79	4318.81+
1977	701.59	4202.06+
1978	1011.38	4239.19+
1979	857.44	4147.74
1980	1033.00	4712.27
1981	720.46	4864.42
1982	708.85	5091.21
1983	780.61	4290.81
1984	601.89	3885.92
1985	729.57	4015.70

* Based on indexes given in Beattie (1975).
+ Estimated (See earlier text).

Table A10a. Monthly Native-origin Charcoal Prices, By Planning Region[1], for 1982.
(Actual Cruzeiros)

Month	Region I	Region II	Region III	Region IV	Region V	Region VI
January	2,145	2,485	2,100	2,200	2,305	2,025
February	2,465	2,565	2,425	2,310	2,810	2,025
March	2,540	3,085	2,800	2,550	3,060	2,275
April	2,450	3,275	3,015	2,910	3,125	2,400
May	2,315	3,275	3,000	2,700	3,475	2,405
June	2,475	3,275	2,915	2,870	3,475	2,400
July	2,785	3,250	2,790	3,310	3,475	2,405
August	2,750	3,525	2,780	3,350	3,475	2,405
September	2,700	3,680	2,825	3,380	3,945	2,405
October	2,650	3,070	2,745	2,950	3,945	2,405
November	2,375	2,965	2,510	3,235	3,945	2,405
December	2,425	2,900	2,805	3,235	3,945	2,405

1 For a map showing the planning regions of Minas Gerais, see Beattie (1975), p 48.

Table A10b. Monthly Native-origin Charcoal Prices, By State, for 1982.
(Actual Cruzeiros)

Month	Minas Gerais	Sao Paulo	Rio de Janeiro	Bahia
January	2,210	1,770	2,185	2,230
February	2,435	2,040	2,285	2,320
March	2,720	2,635	2,875	2,435
April	2,860	2,745	3,050	2,460
May	2,860	3,155	3,360	2,410
June	2,900	3,450	3,500	2,885
July	3,000	3,310	3,770	3,390
August	3,050	3,185	3,945	3,230
September	3,155	3,395	3,950	4,325
October	2,960	2,760	3,845	4,350
November	2,905	2,670	3,820	4,500
December	2,955	2,930	3,885	4,800

Table A11a. Monthly Native-origin Charcoal Prices, By Planning Region, for 1983.
(Actual Cruzeiros)

Month	Region I	Region II	Region III	Region IV	Region V	Region VI
January	2,525	2,908	2,967	3,175	3,950	2,472
February	3,350	4,051	3,808	3,609	3,945	2,660
March	3,742	3,496	4,492	4,018	3,945	3,035
April	5,676	5,683	7,008	6,217	9,223	5,500
May	7,392	7,229	7,917	6,942	9,445	6,200
June	7,833	8,171	8,271	7,255	10,000	6,400
July	9,367	10,025	10,050	8,277	13,890	7,937
August	10,900	11,438	10,858	10,217	15,002	9,350
September	11,275	11,625	10,725	10,525	13,375	9,300
October	11,040	11,489	11,300	10,600	13,500	9,300
November	11,200	11,500	11,600	10,800	13,800	9,300
December	13,630	12,850	13,420	12,580	15,700	10,700

Table A11b. Monthly Native-origin Charcoal Prices, By State, for 1983.
(Actual Cruzeiros)

Month	Minas Gerais	Sao Paulo	Rio de Janeiro	Bahia
January	2,999	2,808	4,197	4,463
February	3,572	3,473	4,106	4,625
March	3,788	4,237	4,547	4,555
April	6,551	4,261	5,945	4,965
May	7,521	5,719	6,962	5,340
June	7,988	6,464	7,753	6,882
July	9,908	6,662	8,432	8,500
August	11,294	7,823	9,071	7,925
September	11,115	8,654	11,450	8,800
October	11,183	8,830	11,800	11,622
November	11,400	10,800	12,700	11,400
December	13,150	11,250	15,300	11,800

Table A12a. Monthly Native-origin Charcoal Prices, By Planning Region, for 1984.
(Actual Cruzeiros)

Month	Region I	Region II	Region III	Region IV	Region V	Region VI
January	15,000	14,815	16,050	13,915	17,965	12,348
February	15,700	15,955	15,875	14,950	18,380	12,965
March	14,815	15,605	14,560	15,065	18,380	12,750
April	14,435	15,565	14,465	14,915	18,380	12,400
May	15,110	16,140	16,705	16,000	18,380	12,475
June	16,540	16,755	18,265	16,590	19,035	14,400
July	18,985	19,575	19,650	18.645	23,000	15,740
August	21,115	23,190	23,160	21,100	26,825	18,650
September	23,370	25,230	25,740	22,545	30,325	20,140
October	27,060	28,830	28,790	25,570	33,300	22,330
November	32,925	34,600	36,610	30,945	40,290	26,820
December	37,990	41,000	39,475	37,548	48,000	31,950

Table A12b. Monthly Native-origin Charcoal Prices, By State, for 1984.
(Actual Cruzeiros)

Month	Minas Gerais	Sao Paulo	Rio de Janeiro	Bahia
January	14,970	11,815	15,960	12,450
February	15,640	13,320	16,870	15,050
March	15,195	13,725	16,400	17,050
April	15,030	15,010	17,100	16,555
May	15,800	16,030	19,315	16,775
June	16,940	15,465	22,145	16,775
July	19,265	15,460	22,280	16,775
August	22,340	18,400	28,990	22,250
September	24,560	20,380	30,135	22,500
October	27,650	23,800	34,600	34,250
November	33,700	28,531	41,952	38,000
December	39,312	31,125	43,794	38,000

Table A13a. Monthly Native-origin Charcoal Prices, By Planning Region, for 1985.
(Actual Cruzeiros)

Month	Region I	Region II	Region III	Region IV	Region V	Region VI
January	51,572	51,166	53,231	46,674	58,265	41,500
February	75,691	82,166	74,249	85,925	87,605	73,175
March	77,283	83,375	74,833	87,309	85,000	70,937
April	79,770	84,031	84,416	88,013	90,250	71,750
May	80,958	84,562	86,082	88,623	92,000	73,687
June	80,133	84,312	80,833	85,006	92,000	74,500
July	79,300	84,125	81,624	81,749	92,000	74,500
August	81,000	84,750	85,666	82,833	94,500	74,500
September	82,083	85,125	88,166	83,333	97,425	74,775
October	83,437	86,587	92,999	87,312	103,350	75,393
November	109,222	115,164	109,444	106,157	133,866	87,941
December	130,666	139,646	130,333	125,333	160,425	114,250

Table A13b. Monthly Native-origin Charcoal Prices, By State, for 1985.
(Actual Cruzeiros)

Month	Minas Gerais	Sao Paulo	Rio de Janeiro	Bahia
January	50,484	43,450	49,669	55,000
February	77,736	48,400	79,816	60,000
March	79,789	63,400	84,375	60,000
April	82,725	72,940	89,468	77,000
May	84,318	83,175	74,602	84,000
June	82,787	81,962	100,461	84,000
July	82,216	81,962	107,262	110,000
August	83,874	93,375	96,800	110,000
September	85,151	93,375	107,697	110,000
October	88,179	102,712	121,666	120,000
November	110,299	112,500	141,573	120,000
December	133,442	127,500	160,606	120,000

Table A14a. Monthly Native-origin Charcoal Prices, By Planning Region, for 1986.
(Actual Cruzeiros)

Month	Region I	Region II	Region III	Region IV	Region V	Region VI
January	138,171	150,300	156,083	138,667	175,400	125,125
February	160,300	177,762	177,416	161,100	206,700	139,315
March	168.50	183.20	178.00	172.10	212.50	144.85
April	184.89	192.09	201.71	182.13	222.50	159.51
May	231.50	243.96	228.67	210.08	276.25	194.00

Table A14b. Monthly Native-origin Charcoal Prices, By State, for 1986.
(Actual Cruzeiros)

Month	Minas Gerais	Sao Paulo	Rio de Janeiro	Bahia
January	147,291	129,375	168,395	132,500
February	170,517	138,750	180,000	174,210
March	176.53	140.00	180.00	195.17
April	190.48	----	----	----
May	230.75	----	----	----

Table A15. Brazilian Steel Production and Consumption of Charcoal.

Year	Steel Production With Coal (Met. Tons)	Steel Production w/Charcoal (Met. Tons)	Total Steel Production (Met. Tons)	Consumption of Charcoal in Steel Mfg. (m^3)
1974	3,342,676	2,225,806	7,507,220	5,653,547
1975	4,050,240	2,519,353	8,308,046	6,600,705
1976	4,500,234	2,494,818	9,168,899	5,787,978
1977	6,223,040	2,598,242	11,163,755	6,521,587
1978	6,872,834	2,638,977	12,106,921	6,201,595
1979	8,028,493	2,789,437	13,891,101	7,085,170
1980	8,681,660	3,117,868	15,338,957	8,449,422
1981	7,095,336	2,916,025	13,320,460	8,835,556
1982	7,035,468	2,841,261	12,996,417	8,410,133
1983	8,528,995	2,844,102	14,670,618	8,503,865
1984	10,740,056	3,402,907	18,385,164	10,167,886

Table A16. Pig Iron Production and Consumption of Charcoal.

	Production with Charcoal				Total	Consumption of Charcoal		
Year	Production With Coal	Integrated Mills	Independent Mills	Total	Pig Iron Production	Integrated Mills	Independent Mills	Total
1974	2,689,115	1,730,211	1,426,688	3,156,899	5,846,014	5,646,000	5,393,000	11,039,000
1975	3,422,745	1,866,952	1,742,968	3,629,920	7,052,665	6,605,000	6,588,000	13,193,000
1976	4,141,326	1,866,925	2,132,925	4,028,902	8,170,228	5,798,000	8,062,000	13,860,000
1977	5,537,281	1,979,375	1,863,716	3,843,091	9,380,372	6,512,000	7,045,000	13,557,000
1978	6,198,938	1,936,795	1,907,314	3,844,109	10,043,047	6,192,000	7,210,000	13,402,000
1979	7,281,880	2,104,643	2,326,891	4,431,534	11,713,414	7,074,000	8,656,000	15,730,000
1980	7,743,887	2,494,375	2,447,021	4,941,396	12,685,283	8,453,000	8,980,000	17,433,000
1981	6,425,515	2,380,524	1,989,491	4,370,015	10,795,530	8,829,000	7,122,000	15,951,000
1982	6,702,699	2,377,581	1,747,062	4,124,643	10,827,342	8,422,000	6,624,000	15,046,000
1983	8,091,011	2,386,785	2,466,725	4,853,510	12,944,521	8,517,000	8,978,000	17,495,000
1984	10,744,429	3,005,412	3,483,553	6,488,965	17,233,394	10,168,000	12,819,000	22,987,000

Table A17. Brazilian Iron Alloy Production and Consumption of Charcoal.

Year	Iron Alloy Production w/Charcoal (Met. Tons)	Total Iron Alloy Production (Met. Tons)	Consumption of Charcoal in Iron Alloy Mfg. (m^3)
1974	210,715	218,673	438,287
1975	251,139	256,671	522,369
1976	300,980	312,765	626,038
1977	363,472	372,144	756,021
1978	397,842	410,497	827,511
1979	468,742	485,149	974,983
1980	532,946	552,672	1,108,527
1981	543,605	564,069	1,543,357
1982	537,350	563,897	1,412,397
1983	570,436	580,723	1,853,183
1984	667,823	681,453	2,170,424

Table A18. Brazilian Pig Iron Exports.

Year	Metric Tons Exported	Value US$ FOB
1974	252,255	30,899
1975	510,524	65,698
1976	774,947	79,356
1977	850,605	88,872
1978	1,026,480	111,501
1979	989,343	131,789
1980	841,331	119,471
1981	714,446	87,180
1982	677,360	80,035
1983	1,808,125	184,924
1984	2,484,394	267,495

Table A19. Brazilian Iron Alloy Exports.

Year	Metric Tons Exported	Value US$ FOB
1974	43,868	19,415
1975	60,712	47,768
1976	86,768	78,081
1977	113,555	80,402
1978	147,199	124,750
1979	163,073	164,768
1980	164,206	176,131
1981	252,013	217,937
1982	224,909	167,210
1983	345,801	203,341
1984	291,573	226,156

Table A20. Consumption of Charcoal in Cement Production in Brazil. (m^3)

Year	Region: North	North-East	West-Central	South-East	South	Total
1980	4,072	44,700	21,420	585,364	144	655,700
1981	69,536	206,460	89,588	694,640	---	1,060,224
1982	245,720	420,684	215,652	895,556	2,168	1,779,900
1983	276,004	927,160	358,144	967,949	---	2,529,257
1984	295,863	1,157,008	531,870	1,229,097	1,313	3,215,151

Table A21. Consumption of Charcoal in Other Primary Metals Industries. (m^3)

Year	Lead	Tin	Nickel	Silicon	Zinc	Total
1980	360	16,400	---	---	240,000	256,760
1981	452	10,400	---	---	265,000	275,852
1982	1,808	11,992	276	138,512	270,000	422,588
1983	3,664	22,052	205,256	151,480	250,000	632,452
1984	792	32,616	298,392	152,688	250,000	734,488

Table A22. Prices of Brazilian National Coal and Diesel in Brazil. (Actual Cruzeiros)

Year	Metallurgical Coal	Coal for Energy: Parana	Santa Catarina	Rio Grande du Sul	Diesel
1972	----	45.12	90.36	57.54	0.586
1973	----	51.44	104.47	66.50	0.655
1974	----	61.72	133.24	89.80	0.887
1975	----	81.75	185.89	113.34	1.340
1976	----	114.91	229.03	142.98	2.266
1977	----	153.24	314.42	202.79	3.166
1978	----	226.57	480.05	291.42	4.500
1979	1,764.36	393.86	866.07	475.24	7.975
1980	3,236.75	689.24	1,547.60	857.61	14.333
1981	7,313.15	2,217.79	3,902.30	2,229.15	34.100
1982	16,937.09	5,351.00	8,999.27	5,141.21	73.666
1983	35,482.80	10,634.73	25,248.39	11,215.37	191.000
1984	105,301.00	31,567.22	65,224.81	32,778.28	623.200
1985	308,955.00	65,491.50	136,625.34	68,363.50	1,837.000

Table A23. Exchange Rates, Price Indexes, Brazilian Real National Income, and Gross National Product.

Year	Exchange Rate Cruzeiros Per U.S.$	Brazilian Consumer Price Index	Brazilian Wholesale Price Index	U.S. Producer Price Index	Real National Income (1980 Cr$)	Gross Domestic Product (1980 Cr$)
1967	2.66	2.7	2.2	39.5	3,681.8	4,620
1968	3.40	3.2	2.8	36.4	4,107.1	5,145
1969	4.07	4.0	3.3	37.3	4,636.4	5,650
1970	4.59	4.9	4.1	38.6	4,487.8	5,795
1971	5.29	5.9	4.9	40.0	5,000.0	6,492
1972	5.93	6.8	5.8	41.5	5,586.2	7,213
1973	6.13	7.7	6.7	42.9	6,776.1	8,191
1974	6.79	9.8	8.7	45.8	7,643.7	8,987
1975	8.13	12.7	11.1	56.0	8,504.5	9,474
1976	10.67	18.0	15.9	62.4	9,547.2	10,395
1977	14.14	25.8	22.6	66.4	10,278.8	10,992
1978	18.07	35.8	31.1	71.0	11,247.6	11,542
1979	26.95	54.7	48.4	76.2	12,076.4	12,280
1980	52.71	100.0	100.0	86.1	12,125.0	13,164
1981	93.12	205.6	208.2	100.0	11,213.3	12,959
1982	179.51	407.0	399.8	110.7	12,206.5	13,079
1983	577.04	984.9	1,072.5	113.7	11,774.5	12,666
1984	1,848.03	2,922.5	3,605.3	114.9	12,370.8	13,236
1985	6,465.70	9,550.0	11,662.0	117.4	---	---
1986	(10,000 +)	---	---	---	---	---