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Subsidies and Cattle Production in the Amazon: An Economic Policy Analysis

*Emily McClain, Catherine Halbrendt,
Jennifer Sherbourne, and Conrado Gempesaw¹*

Abstract: Cattle production has been a major source of agricultural deforestation in Brazil's Amazon rainforest. Brazilian credit subsidies have been blamed for speeding cattle expansion and thus deforestation. A stochastic coefficients regression approach was used to quantify the effects of credit subsidies and world prices on cattle numbers in five Amazon regions for the 1963–83 period. Results show that cattle production has been positively correlated to both prices and credit. Elasticities show that these relationships strengthened over time and that production has been more responsive to credit than to world prices.

Introduction

The international scientific community continues to strengthen the link between deforestation and global climatic change. With an increased focus on deforestation, there is a need to identify and quantify the forces leading to it. Of particular interest are those factors subject to direct control, such as government policies.

Brazil, estimated to hold one-third of the world's rainforests in its Amazon Basin, has received harsh international criticism over the acceleration of deforestation, which began in the 1970s. While it is uncertain how much of Brazil's rainforest has been cleared, estimates range from 5.1 percent (Brazilian government) to 12 percent (Browder, 1988). In either instance, a large area has been deforested.

Environmental issues present difficult challenges for policy makers, particularly in developing countries such as Brazil. Environmental protection must balance economic development, where policy options, funding, and expertise are extremely limited. During the 1980s, Brazil's economy was increasingly unstable. Inflation reached almost 1,800 percent for 1989, and Brazil closed the decade with little real improvement in living standards.

Austerity programmes in recent years have forced cuts in crucial areas such as infrastructural maintenance, social programmes, and agricultural support, making it difficult to divert funds for the environment, funds that must compete with basic services in the world's sixth most populous country. Given such financial limitations, one obvious option for "bargain" environmental protection is to reexamine and identify public policies that may contribute to irrational deforestation, especially those that could be eliminated with cost savings or little additional expenditure on the part of the Brazilian government. In the late 1980s, one of Brazil's most applauded moves was the temporary suspension of tax credits and fiscal incentives for frontier (Amazon) farming. Worldwide, agriculture is estimated to be responsible for 76 percent of all deforestation (Keipi and Valdares, 1989), and, for Brazil's Amazon, it is estimated that cattle ranching uses twice as much land as cropping (Lewandrowski and McClain, 1990). Government policies that promoted the expansion of cattle production have been widely criticized in the literature as a major contributor to Amazon deforestation (Fearnside, 1986; Browder, 1988; and Mahar, 1989).

No studies have empirically linked credit subsidies (a major source of funding) with cattle production expansion within the Amazon. Brazil's subsidized agricultural credit programme has been criticized as ineffective because funds are often spent on nonagricultural enterprises and investments. If a positive relationship can be established between subsidies and cattle numbers, more credence can be given to the argument for their permanent elimination. If the subsidies are not the overwhelming motivation for cattle expansion, it becomes important to determine what factors are driving ranching in frontier areas in order to slow expansion and deforestation.

This paper examines the relationship between government subsidies (Brazilian policies), world beef prices (other countries' policies), and cattle numbers in the Amazon. Thus, credit

subsidies and world prices are indirectly linked to deforestation through their influence on cattle production.

Study Area

The Legal Amazon was divided into five geographic regions to capture differences in producer policy responses that are due to climatic, geographic, market, and regional policy differences. Four regions are individual states that account for 90 percent of all Amazon cattle production: Maranhão, Goiás (now two states: Goiás and Tocantins), Pará, and Mato Grosso (now Mato Grosso do Sul and Mato Grosso). Region five, the rest of the Amazon (ROA), is an aggregate of five states or territories: Amazonas, Amapá, Roraima, Acre, and Rondônia.

In geographical and development terms, Brazil is usually classified into five regions: North, Northeast, Centre-West, South, and Southeast. The Legal Amazon encompasses the North, plus parts of the Northeast and Centre-West. Cattle expansion has varied throughout Brazil due to the differences in land availability, ranch sizes, and government policies that tended to favour certain interest groups or locals. Rates of cattle expansion were phenomenal in the Amazon when compared to southern Brazil, the largest cattle-producing region. During 1962–85, cattle expansion rates were 271 percent, 105 percent, and 130 percent for the North, Northeast, and Centre-West, regions, respectively, but only 35 percent for the South and Southeast (non-Amazon) regions. Government development programmes probably contributed to these rapid growth rates in the Amazon.

Background Information

In the early 1960s, Brazil decided actively to develop the Amazon for two main reasons: to defend Brazil's borders and to exploit the region's vast wealth and agricultural potential (Mahar, 1979). Later, the Amazon became an outlet for the poor of the Northeast and a way to alleviate land-reform pressures using migration policies.

Initial attempts at development came through the construction of the 2,000 km Belém-Brasília highway, completed in 1964. After establishing this north-south road link, the government launched Operation Amazônia in 1966. The plan's goal was to attract large-scale corporate investment to the region; corporate cattle ranching was identified as a promising enterprise because the region's fragile tropical soils were best suited for pasture and also because of an FAO study that indicated that Brazil could be a world-class beef exporter.

As a result, a massive infusion of credit subsidies occurred. During 1968–70, the subsidy grew from \$848,000 to \$33 million (Browder, 1988). Cheap land, low labour requirements, flexible marketing, and low maintenance costs also contributed to rapid cattle expansion. Livestock producers could receive subsidized financing for production, marketing, and investment activities under the national programme for rural credit (one of the government's main agricultural support programmes).

In the early 1970s, the Brazilian government changed its Amazon development strategy, giving priority to colonization and increased migration. Funding for livestock enterprises decreased during 1970–74 by 7 percent as funds were diverted to a colonization programme of the National Colonization and Land Reform Institute. Consequently, cattle expansion rates decreased in almost every region of the Amazon during the period, compared to annual rates of increase of 10 percent during 1962–70.

The beef sector was restimulated in 1975 by Brazil's National Development Plan, prompted by the 1973 oil price shock and the need to increase foreign exchange earnings. Since beef was becoming an important export, cattle production incentives were increased. The 1975 plan prompted a subsequent plan, the Brazilian National Cattle Plan, to stimulate beef production in regions where expansion had stagnated under decreased funding and high production costs. Other programmes, the Livestock Development Programme, the National

Pasture Programme, and the Livestock Herd and Management Programme, were developed and implemented. Cattle production responded rapidly in the Amazon, with an expansion of 31 percent in the North, 20 percent in the Centre-West, and 24 percent in the Northeast during 1974–79 (IBGE).

During the 1980s, cattle expansion continued but the pace slowed, perhaps due to cuts in government funding. Much of the Amazon region showed a food deficit in the 1970s. Although several factors could have stimulated Brazil's cattle industry, this study examines the roles of the much-maligned government subsidies and world prices in promoting cattle production during the 1969–83 period, when both cattle and deforestation expanded rapidly.

Model Development

Theory suggests that production is a function of prices and supply shifters, which in this study are government subsidies. Tax credits offered to corporate livestock operators were added to expenditures under the national agricultural subsidized credit programme to represent direct transfers to the agricultural sector by the government. Although not ideal, the aggregation was needed to reduce the numbers of regressors, given the small sample size.

The end of slaughter and export quotas in the Brazilian beef sector in 1971 meant that international prices may have influenced the evolution of ranching for most of the period. Thus, a world price variable was included in the analysis. If significant, one may infer that policies in beef exporting and importing countries that affected world prices may also have influenced cattle production and, indirectly, deforestation in the Amazon. Theoretically, the domestic price of beef and prices for commodities competing in the production of cattle should also be considered. However, competing enterprises are difficult to identify, and a reliable series of domestic beef prices could not be compiled due to high inflation rates and aggregation in reporting.

Finally, an interactive dummy variable was used to separate the oil shock period of 1974–79 from the rest of the observations. The oil shock period also coincided with domestic beef shortages that caused a draw-down of cattle inventories. The dummy variable is interactive with the aggregate credit term, changing the slope of the equation during the 1974–79 period.

The general specification of the empirical model is:

$$(1) \text{ CATTLENO}_{it} = \beta_0 + \beta_1 \text{GOVTSUB}_{it} + \beta_2 \text{PRICE}_{t-3} + \beta_3 (\text{DUM}_{it} \text{GOVTSUB}_{it}) + e_{it}$$

Cattle numbers (*CATTLENO*) in the *i*th region in time *t* are expressed as a function of world beef prices (*PRICE*) lagged three periods, an aggregate term representing government subsidies (*GOVTSUB*) in the *i*th region, and a dummy variable (*DUM*). The configuration of the dummy variable is *DUM* = 1 for all periods where *t* > 1973 and < 1979; otherwise *DUM* = 0.

The availability of tax credit data limited the study period to 1969–83, or 14 total observations. Cattle numbers and subsidized credit expenditures by region were obtained from the *Anuário Estatístico do Brasil* (IBGE). Tax credits were available from a secondary source, and both credit series were deflated to a mid-1980 base period using a general price index (IBGE). World prices were assumed to be utility beef prices in \$/t, f.o.b. US Gulf. Prices were lagged and converted to domestic currency to include the effects of exchange rate policy (over- or under-valuation) on producer (exporter) incentives for cattle production.

In pre-test experiments, the un-lagged *GOVTSUB* term was more important than lagged terms in explaining variation in cattle numbers. *A priori*, it is expected that credit under the rural credit system (production, marketing, and investment) should have some lagged effect, but this did not show up in the aggregate credit term. Some lag may be inherent in the data since credit is issued early in the year and cattle inventories made late in the year. *A priori*, positive coefficients were expected for *PRICE* and *GOVTSUB*, while a negative coefficient was

expected on *DUM* due to the contractionary impacts of the oil shocks on Brazil's economy and domestic beef shortages.

Elasticities for both price and credit were expected to be inelastic (less than 1.0), since cattle production is characterized by large initial investments. Costs of acquiring and clearing land, plus pasture establishment, are substantial, but, once this investment occurs, large reductions in price or credit are necessary to remove area from production and reduce cattle numbers. Cattle are primarily forage-fed; thus, carrying costs are low and producers respond to low prices by withholding cattle from markets.

Estimation Method

Conventionally, fixed coefficient models with dummy variables such as ordinary least squares (OLS) are used to capture policy impacts on the structure of a sector. The large numbers of cattle development programmes instituted during the time period plus the volatility of Brazilian sectoral and macroeconomic policies during the period make conventional modelling unusually difficult and questionable. The timing and net effects of political and structural adjustment on the livestock sector would be hard to hypothesize.

Since a fixed coefficient estimation method assumes constancy in the marginal contribution of causal factors, OLS was considered to be too restrictive when evaluating the impacts of government subsidies on cattle production. Over time, investments in research and infrastructure would have changed the way producers respond to policy and policy changes. With no strong theoretical grounds for choosing linear specifications, a stochastic coefficient regression approach (SCM) developed by Swamy and Tinsley was used in this study (Swamy and Tinsley, 1980).

Reasons for choosing the SCM approach included functional form specifications, changes in technology such as breeding and pasture, and the ability to accommodate changing structural parameters. The SCM can adequately represent several forms of nonstationary processes and can respond quickly to changing economic conditions, yielding predictions that are superior to those from fixed-slope coefficient models.

Estimation Results

Parameter estimates of the SCM model are presented in Table 1. Overall, the results are very good (significant at the 95-percent level), with the exception of the model for Mato Grosso and the coefficient on subsidies for Maranhão. One plausible explanation for the lack of success in explaining cattle expansion in Mato Grosso is that the model ignores the effects of alternative agricultural enterprises. Cattle expansion in Mato Grosso may have been driven by a migration of São Paulo's cattle industry westward as it was displaced by the expansion of sugarcane under Brazil's National Fuel Alcohol Programme in the mid-1970s (USDA).

An FAO study of agricultural credit in the Northeast found that government-subsidized credit for livestock enterprises in Maranhão was being diverted to other investments. This finding is supported by the non-significance and wrong sign of the credit coefficient in the Maranhão equation.

All but three of the credit and price terms were significant and/or positive, indicating that both government subsidies and world prices positively affected cattle expansion in the Legal Amazon during the study period. As hypothesized, all elasticities were inelastic, but in general became more elastic over time (Table 2). Estimates for subsidies in ROA were the most inelastic until 1980. This can be partially explained by the fact that production in this region may have been discouraged by the scarcity of roads and markets in the Amazon's most remote area.

All the elasticities for the oil shock period are less responsive than for the non-oil shock period (i.e., all the dummy variable coefficients were of the expected negative sign). In

addition, comparisons of the variations in elasticities across the five modelled regions show a consistent pattern. This pattern supports SCM's ability to distinguish structural changes through time, as all regions faced similar changes in macroeconomic conditions.

Table 1—Stochastic Coefficients Estimation Results

Coefficient	Goiás	Mato Grosso	Maranhão	Pará	Rest of the Amazon
Intercept	6715.56	7501.48	2186.96	1176.6	1577.42
T-ratio	(19.72)	(0.2)	(113.8)	(35.96)	(26.46)
Subsidy	0.11	0.11	0.01	0.05	0.05
Subsidy (1973–79)	0.16	0.04	0.22	0.01	0.001
T-ratio	(3.02)	(0.02)	(1.41)	(2.21)	(4.06)
World price ($t-3$)	241.75	250.83	23.26	34.7	-68.82
T-ratio	(13.37)	(0.11)	(25.5)	(6.35)	(-4.67)
Dummy	0.05	-0.08	0.21	-0.04	-0.04
T-ratio	(1.87)	(0.02)	(5.88)	(-2.34)	(-5.35)

Note: All estimates are significant at the 95-percent level, except those for Mato Grosso and the credit subsidy parameters for Maranhão.

Implications

The elasticities confirm that government subsidies have indeed played a positive role in expanding cattle production (and implicitly, deforestation) in most regions of the Amazon. It is important to remember topographical differences within the Amazon when attaching importance to this result. Most of the true rainforest falls within the region defined as ROA, while the remaining areas are primarily palm forests, floodplains, or grassland savannas.

The SCM estimates show that cattle numbers in the ROA were highly inelastic in response to subsidies during the first part of the period, but that responsiveness increased rapidly over time, with ROA exhibiting the highest elasticity of all regions in the last year. Thus, the elimination or reduction of credit should be very effective in slowing cattle expansion in rainforest areas.

World price was shown to have a very small negative effect on cattle production in the ROA. This is probably due to the fact that the region has typically been food-deficit; the distance from markets also weakens price transmission to this region. The general increases in the responsiveness of cattle numbers to world prices suggested by the elasticity estimates for all regions is consistent with declining government intervention and loosening of trade restrictions in the beef sector over time. This means that Brazil's 1990 switch to a floating exchange rate and the subsequent devaluation to equilibrium exchange levels now occurring may serve to fuel cattle expansion and exacerbate deforestation. Since cattle numbers were generally more responsive to subsidies than to price signals, price declines would have a smaller impact on cattle production than reductions in credit, *ceteris paribus*.

Note

¹Clemson University, University of Delaware, University of Missouri, and University of Delaware, respectively.

Table 2—Subsidy and Price Elasticity Estimates

Year	Subsidy Elasticities					Price Elasticities				
	Goiás	Pará	Mato Grosso	ROA	Maranhão	Goiás	Pará	Mato Grosso	ROA	Maranhão
1969	0.129	0.120	0.081	0.003	0.006	0.138	0.133	0.137	-0.030	0.053
1970	0.198	0.630	0.143	0.033	0.014	0.119	0.116	0.120	-0.027	0.048
1971	0.276	0.410	0.214	0.008	-0.067	0.105	0.118	0.108	-0.027	0.051
1972	0.274	0.530	0.214	0.025	-0.061	0.111	0.124	0.112	-0.028	0.053
1973	0.251	0.106	0.213	0.119	-0.022	0.139	0.137	0.138	-0.032	0.065
1974	0.187	-0.087	0.175	0.036	-0.360	0.201	0.233	0.193	-0.052	0.123
1975	0.284	-0.053	0.167	0.013	-0.350	0.188	0.239	0.207	-0.058	0.129
1976	0.299	-0.051	0.165	0.080	-0.404	0.216	0.275	0.244	-0.068	0.157
1977	0.322	0.028	0.188	0.137	-0.401	0.202	0.254	0.229	-0.061	0.144
1978	0.399	0.159	0.277	0.197	-0.342	0.137	0.165	0.156	-0.039	0.096
1979	0.424	0.208	0.321	0.250	-0.257	0.137	0.159	0.153	-0.038	0.092
1980	0.406	0.326	0.378	0.448	0.126	0.186	0.186	0.185	-0.042	0.104
1981	0.355	0.364	0.351	0.528	0.104	0.252	0.217	0.243	-0.052	0.143
1982	0.196	0.305	0.212	0.619	0.054	0.419	0.327	0.396	-0.078	0.231
1983	0.225	0.359	0.216	0.673	0.064	0.415	0.314	0.406	-0.072	0.239
Minimum	0.196	-0.087	0.081	0.003	-0.404	0.105	0.116	0.108	-0.078	0.048
Average	0.282	0.224	0.221	0.211	-0.126	0.198	0.200	0.202	-0.047	0.115
Maximum	0.424	0.630	0.378	0.673	0.126	0.419	0.327	0.406	-0.027	0.239
Avg. 1974-79	0.319	0.034	0.216	0.119	-0.352	0.180	0.221	0.197	-0.053	0.124

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Discussion Opening—Gervásio Castro de Rezende (Instituto de Pesquisa Econômica Aplicada, Brazil)

The authors included a dummy variable, interactive with the credit term, for the 1973-79 period, based on the argument that in this period there were "beef shortages that caused a draw-down of cattle inventories," loosely attributed to the oil shocks. This does not seem plausible; a closer look at the Brazilian data on livestock herd and beef cattle slaughter reveals what really happened in this period. The "draw-down" of cattle inventories of which the authors speak actually occurred only during 1970-73 (i.e., before the first oil shock) and was due to the fact that the data were collected, up to 1970, by the Ministry of Agriculture and, from 1973, by IBGE. Because these institutions' methodologies were different, the two series are not comparable; e.g., the Ministry of Agriculture's estimate of cattle numbers in Brazil for 1970 is 98 million head, while that of IBGE for 1973 is only 90 million.

If the authors are able to circumvent this problem and revise their paper, some additional comments are appropriate. First, the data for Brazil show that the cattle numbers series contains a clear cyclical component, which conforms to the livestock cycle (about which there is not a single word in the paper). Since one cannot expect pasture area to adhere to this cycle, it is questionable whether inferences about deforestation are valid. (The same is true in regard to comparison of long-run trends, since there has been much pasture improvement in Brazil.) In this connection, the finding that the credit variable enters with no lag in the equations (contrary to theoretical expectations) may have to do with its pro-cyclical behaviour.

There was no reason to use world beef prices, since data on domestic beef cattle prices have existed at the state level since 1966.

It is not clear whether credit volumes or credit subsidies were used; since the subsidy rate varied wildly during the period, the two series present very different behaviour. In any case, the aggregation of credit volumes and tax credits does not make sense.

[Other discussion of this paper and the authors' reply appear on the following page.]

General Discussion—Léo da Rocha Ferreira, Rapporteur (Instituto de Pesquisa Econômica Aplicada, Brazil)

Discussion on the Herrmann *et al.* paper concentrated on the model specification. Herrmann agreed that many other factors could be considered in order to improve wider understanding of food aid and food trade. The exogenous or endogenous nature of imports was discussed. It was also argued that emergency aid is no answer to food problems and that relative prices are distorted in the developing countries.

On the Tyers paper, the author stressed that the application of “standard” but inappropriate models misinforms and misleads conclusions and policy implications and the necessity to include the combination of explicit food price risk with dynamic behaviour and market insulating policies. However, the stochastic effects were not elaborated in the paper. Other topics discussed were whether trade promotes sustainable agriculture, whether the paper’s results might underestimate the welfare gains due to reducing insulation (since agents are risk averse), and whether the design of commodity programmes worldwide indicates that their purpose is to raise income rather than to reduce variability. Other comments were that models are not effective in sustainable agriculture, that risk aversion was properly included in the paper, and that farmers are more interested in income policies. Finally, it was argued that the more simple the model, the more powerful it is, and that protection is not supposed to yield welfare improvements.

The focus of the discussion on the McClain *et al.* paper was on the data used in the study, where two different methodologies resulted in two series that were not comparable (methodologies used by the data source). The role of informal credit and the sequence of causality from credit subsidies to more beef, to more pasture area, and to more deforestation were also discussed. Macroeconomic and trade policy are important in making land investment more attractive as a hedge against inflation and consequently a more powerful force for deforestation. Finally, it was argued that the authors were unable to quantify several variables and were unaware of informal credit.

Participants in the discussion included N. Devisch (Boerenbond, Belgium), M. Hartmann (Universität Frankfurt), J. Kola (Agricultural Economics Research Institute, Finland), J. Lundy (University of California), H.A. Mahran (University of Gezira), L.R. Sanint (CIAT), D. Tomić (Economic Institute, Yugoslavia), and L. Tweeten (Ohio State University).