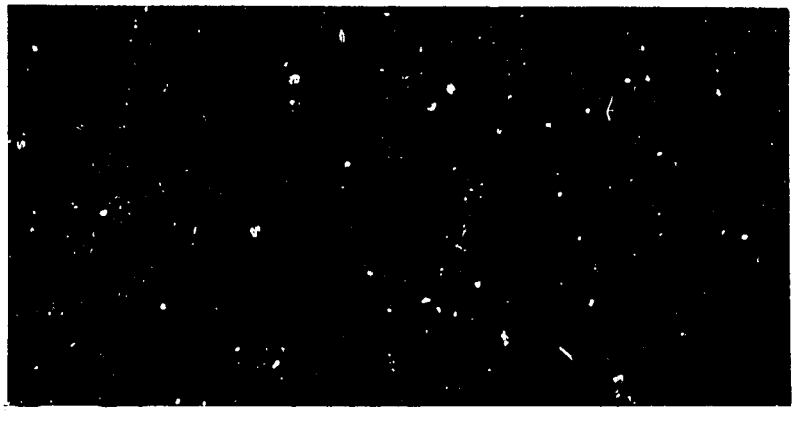
PN-AAS-775
ISN:40110

SMALL RUMINANT

COLLABORATIVE RESEARCH SUPPORT PROGRAM

TECHNICAL REPORT SERIES

NUMBER



STATISTICAL ANALYSIS OF SMALL RUMINANT SUPPLY IN CEARA STATE, NORTHEAST BRAZIL

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Number 37

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January, 1984

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PREFACE

This report summarizes the results of the senior author's Master of Science Thesis research conducted in the Department of Agricultural Economics, Federal University of Ceará, Fortaleza, Brazil. This research was a joint activity between the above Department, the EMBRAPA National Goat Research Center in Sobral, and the Winrock International Sub-Program in Agricultural Economics of the Small Ruminant Collaborative Research Support Program. This collaborative research was initiated during late-1980 and continued through 1981.

The research reported here is one of a coordinated series of studies dealing with economic aspects of small ruminant production and marketing in northeast Brazil. A companion study was prepared which established relationships between the supply of sheep/goat skins and selected economic, biological, and climatic factors. Other research has focused on whole-farm modelling of sheep and goat activities to allow assessment of the likely impact of selected technological changes on whole-farm economic results.

The authors gratefully acknowledge the contributions of the senior author's thesis advisor, Dr. Mario Amin, formerly of the Department of Agricultural Economics, Federal University of Ceará; Dr. Elino Alves, former Director of the National Goat Research Center (CNPC) at Sobral and Dr. Luis Carlos Freire, Director, CNPC for their support of our research program in Brazil.

Principal funding for this research is provided by a sub-grant to Winrock International from the University of California, Davis, through U.S. Agency for International Development Grant No. AID/DSAN/XII/G-0049 in collaboration with the Brazilian Enterprise for Agricultural Research (EMBRAPA) through the National Goat Research Center, Sobral, Ceará, Brazil.

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ENGLISH ABSTRACT--In the state of Ceará, the variation in the supply of agricultural products in the market reflects extremes of seasonal climatic variation and relative price relationships. This work had the objective of developing an econometric model of sheep and goat inventories and supply for slaughter as well as an empirical analysis of producer behavior in relation to marked variations in weather. Two-stage least squares method was used to estimate the model parameters. Inventories of sheep and goats were formulated as a function of prices, weather conditions and lagged inventories, presenting similar results in both cases and reflecting similar production and price structures. The short run price elasticity was -0.07 for goats and -0.18 for sheep demonstrating the producers negative response to a positive change in prices since they anticipate further price increases and increase inventories accordingly.

Index terms: Sheep and goats supply, econometric model, inventories, slaughter supply.

UM MODELO DE OFERTA PARA PEQUENOS RUMINANTES
NO ESTADO DO CEARA, BRAZIL

PORTUGUESE ABSTRACT--No estado do Ceará têm sido frequentes os períodos caracterizados por quedas na oferta de produtos agropecuários como consequência das extremas estacionalidades climáticas. Este trabalho teve como finalidade desenvolver um modelo econométrico de inventário e oferta para abate de ovinos e caprinos no estado do Ceará, como também fazer uma análise empírica do comportamento dos produtores diante de duas decisoes básicas frente às variaçoes bruscas do clima. A estimativa do modelo foi feita usando-se o método dos mínimos quadrados ordinários em dois estágios. Os inventários de caprinos e ovinos foram formulados em termos de preços, condiçoes climáticas e inventários de animais no período anterior, apresentaram resultados semelhantes em ambos rebanhos, o que reflete estruturas de produção e preços semelhantes. As elasticidades de preço à curto prazo foram -0.07 para caprinos e -0.18 para ovinos, evidenciando que os produtores respondem negativamete a incrementos de preços à curto prazo.

Termos para indexação: Oferta de caprinos e ovinos, modelo econométrico, inventários, oferta para abate.

1. INTRODUCTION

Sheep and goats are found in several regions in the world but they are of major economic importance in only a few areas in a small number of countries. One such region is northeast Brazil.

Data from the "Anuario Estatístico do Brasil" estimates that the Brazilian small ruminant population reached 26 million head in 1979, of which 18 million are sheep and 8 million are goats (FIBGE 1980, p. 378). In Brazil there are two major areas of sheep and goat production:

the Southern Region where production of wool sheep is predominant and the Northeastern Region which has major concentrations of hair sheep (90 percent of the national population (Fitzhugh, 1983, p. 125)) and 92 percent of the national goat population (FIBGE 1980, p. 378).

The Northeast Region is characterized by precipitation patterns defined by low levels and irregular distribution in time and place. The State of Ceará is one of the nine states of the Northeast Region, with a population of 808,000 goats and 1,219,000 sheep (FIBGE 1980, p. 378). Variations in animal prices and the availability of feed from grazing lands present to the producer the alternative of either selling small ruminants, keeping them for additional growth, increasing the breeding stock inventory, or maintaining inventories in anticipation of further price increases. When prices increase, we hypothesize that producers will try to keep the females to increase the reproductive herd with the expectation of even higher prices that will be received from the offspring. In the short run, supply should decrease and consequentially prices should increase further. As this process continues, sales for slaughter will eventually increase and prices will then decrease with the expectation of further price decreases in the future (Reeves and Hayman 1975).

The objective of this work was to develop an econometric model of changes in inventories and supply for slaughter of sheep and goats in Ceará, as well as to make an empirical analysis of the producer's response to two alternative decisions that can arise from extreme weather variations. First, during critical periods of drought, producers are forced to sell more than the desired number of animals from their herds. Producers that are able to graze relatively higher proportions of their herds during the drought will be in a better situation to offer their products later on when prices are higher since supply decreases when producers restock. Secondly, since the prices of small ruminants during the drought tend to decrease, this will be reflected in the number of animals slaughtered as well as in reduced slaughter age to minimize the losses in the productive herd/flock. An increased understanding of how sheep and goat producers react to climatic and price changes in Ceará is the object of this study.

2. RESEARCH METHODS

This study utilizes a time series of secondary data obtained over a period of 26 years (1950-1975, see Appendix Tables 1 and 2). This information is sufficient to develop a complete system of structural equations to represent the simultaneous nature of the determination of inventories and slaughterings of sheep and goats in Ceará. Development of the model requires several intermediary steps. In this work the most important steps will be presented explicitly.

2.1. Animal Inventories

Empirical studies suggest that the main determinants of desired inventories (I_t) are expected prices of live animals (P_t) and a vector of variables that shift the functional relationship independently of prices. In this case, the vector is represented by a climatic variable (W_t). The functional relation is expressed as:

$$I_t^* = b_0 + b_1 P_t^* = b_2 W_t. \quad (1)$$

The desired inventory in the equation (1) is not an observable variable. Therefore, variations in the actual inventory (I_t) may be assumed as a proportion (c) of the difference between the desired inventories (I_t^*) and the actual inventory lagged by one period (I_{t-1}) (Koutsoyiannis 1977, p 310-11):

$$I_t - I_{t-1} = c\,(I_t^* - I_{t-1}). \quad (2)$$

The adjustment coefficient (c) indicates that the inventory obtained in period "t" is the same obtained in period "t-1" plus one adjustment. This adjustment corresponds to a proportion "c" of the difference between periods and is assumed to be positive and less than one.

Ignoring the manner in which the expectations are formed, it is possible to use the real price (P) and the climatic variable (W) as "proxies" for price and climatic expectations since the period of time considered is relatively long (Johnston 1971). Accordingly, it is possible to write the inventory equation as:

$$I_t^* = b_0 + b_1 P_t + b_2 W_t. \quad (3)$$

Assuming that other factors remain constant, our hypothesis that greater numbers of animals will be retained in the anticipation of higher prices and favorable climatic conditions, implies that $b_0 > 0$ and $b_2 > 0$.

The climatic variable (W) is defined as a summation of monthly differences between precipitation registered along the 30 pluviometric stations distributed in the Sertao area and the potential evapotranspiration divided by the number of stations (Neto 1981, p 55). This region (the Sertao) has most of the small ruminant population (Gutiérrez 1981, p 8). Substituting (3) into (2) gives:

$$I_t = cb_0 + cb_1 P_t + cb_2 W_t + (1-c) I_{t-1}. \quad (4)$$

Equation (4) can be transformed as follows:

$$I_t = a_0 + a_1 P_t + a_2 W_t + a_3 I_{t-1} \quad (5)$$

which represents the short-run inventory equation and which is now in terms of actual variables. The equation can now be estimated by standard econometric methods. Redefining the equation 5 coefficients as:

$$a_0 = cb_0 \; ; \; a_1 = cb_1 \; ; \; a_2 = cb_2 \; ; \; a_3 = (1-c)$$

it is possible to have the short-run coefficients for the inventory equation defined by a_i (i = 0, 1, 2, 3). Transforming the above equalities into:

$$b_0 = \frac{a_3}{1-a_3}; \; b_1 = \frac{a_1}{1-a_3}; \; b_2 = \frac{a_2}{1-a_3} \text{ and } c = (1 - a_3)$$

results in the long-run coefficients for the inventory equation defined by b_i (i=0,1,2).

2.2. Slaughter Supply Equations

Assuming that the available quantity of animals (Q) at the end of the period (t) could be written as a linear function of the inventories at the end of the last period (t-1), we obtain equation 6:

$$Q_t = a_0 + a_1 I_{t-1} \quad (6)$$

where $a_1 > 0$ represents the growth rate of the herd. It is understood that part of the animals will be used to increase the inventory and the other part goes to the slaughter supply. It is also assumed that the actual value of the inventories during the period studied (1950-75) are not necessarily equal to the desired inventories. Then the total supply for slaughter (A) could be defined as the difference between the available quantity of animals at the end of the period (Q_t) and the change of inventory between periods:

$$A_t = Q_t - d\,(I_t - I_{t-1}) \quad (7)$$

where "d" is $1 > d > 0$, and represents a fraction of the inventory variation within periods.
Substituting (6) and (7) gives:

$$A_t = a_0 + (a_1 + d)\, I_{t-1} - dI_t \quad (8)$$

that represents the total slaughter supply specified in terms of the inventories. Initially, it is possible to predict that producers will slaughter more or less animals based on expectations that are reflected in the inventories at the beginning of the year. Redefining we get:

$$a_0 = e_0 \; ; \; (a_1 + d) = e_1 \; ; \; d = e_2.$$

In summary, we find that there is a simultaneous relationship between inventories and animals supplied for slaughter; consequently the following system of simultaneous equations could be defined as:

$$I_t = a_0 + a_1 P_t + a_2 W_t + a_3 I_{t-1} \quad (9)$$

$$A_t = e_0 + e_1 I_{t-1} + e_2 I_t. \quad (10)$$

2.3. Statistical Specification

The estimated model is linear in the variables and parameters. The endogenous variables are I_t and A_t and the predetermined variables are P_t, W_t, and I_{t-1}. Two sets of equations corresponding to (9) and (10) were estimated, one for sheep and one for goats. Considering the interdependence previously mentioned, the method utilized for estimation of the structural parameters of the model was Two-Stage Least Squares using instrumental variables.

3. RESULTS

The estimated parameters of the structural equations using Ordinary Least Square are presented in Table 1 for sheep and goats. All the coefficients of the estimated equations had the expected sign, confirming the hypothesized relationships. The standard errors for each coefficient serve only as a comparative measure of the statistical significance because of the estimation methods employed. The efficiency and prediction capability for each model was tested by using the "U" coefficient of Theil.[1]

3.1. Estimates of Sheep and Goat Inventories

The equations (1) and (3) in Table 1 represent the goat and sheep inventories. The coefficients of the real price variable (PC_t) for goats and (PO_t) for sheep are 1.083 and 1.842 with positive signs, implying that an increase of one unit in the prices ceteris paribus brings a positive change in the inventory times the value of the respective coefficient.

The estimated short-run price elasticities for sheep and goats using the partial regression coefficients of the variables PO_t and PC_t were equal to 0.16 and 0.075.[2] With a 1% variation in the price of the animals, ceteris paribus, sheep and goat inventories will change by .41% and .17%, respectively. The variable capturing weather effects on inventories (W_t) has values of 0.262 and 0.319. This variable was highly significant in equations 1 and 3 and is linked to the large influence of rainfall on the grazing land of Ceará. The partial regression coefficients of the lagged inventory variable (IC_{t-1} and IO_{t-1}) were 0.578 and 0.619. Coefficient values less than one with a positive sign agree with the theoretical assumptions indicating direct

[1] "U" coefficient is defined as

$$U = \sqrt{\frac{(P_t - A_t)^2}{n}} \Big/ \sqrt{\frac{P_t^2}{n}} + \sqrt{\frac{A_t}{n}}$$

[2] The estimation of short-run price elasticity used the following forumla.

$$e_p = \frac{\partial I_t^i}{\partial P_t^i} \bullet \frac{\overline{P}_t^i}{\overline{I}_t^i}$$

Table 1. Two-Stage Least Square Estimates of Structural Equation Parameters

Species	Equation No.	Constant	Explanatory Variables								R^2	F	d	H
			PC_t	PO_t	W_t	IC_{t-1}	IO_{t-1}	IC_t	IO_t	T				
Goats	1	430.667[a] (149.590)	1.083[c] (0.944)		0.319[b] (0.140)	0.578[a] (0.141)					0.79	26.89	2.13 (ACS)	-0.42 (ACS)
	2	153.163[a] (43.401)				0.129[a] (0.048)		-0.127[b] (0.064)		3.198[a] (0.778)	0.73	19.86	1.10 (INC)	--- ---
Sheep	3	246.651[b] (106.190)		1.842[b] (1.020)	0.262[b] (0.138)		0.619[a] (0.139)				0.89	59.45	2.18 (ACS)	-0.62 (ACS)
	4	111.201[a] (40.039)					0.150[a] (0.048)		-0.146[b] (0.070)	3.666[a] (1.346)	0.77	23.89	1.47 (ACS)	--- ---

Probability levels:
[a]1.0%
[b]5.0%
[c]10.0%

The numbers in parentheses are standard errors.

The a priori signs of each coefficient based on economic theory are as follows:
equation: 1 and 3 - (+) (+) (+)
2 and 4 - (+) (-) (+)

(INC) Nonconclusive region.
(ACS) Nonserial correlation.

relationships between last years inventories and the producer's decision to increase their herds in the current year.

The Durbin "H" statistic was used to test for serial correlation of the residuals in the inventory equations. These values in the sheep and goat equations, respectively, are -0.062 and -0.42 which shows lack of serial correlation in the residual components, at a 95 percent probability level. This test was used because it is the most appropriate when there are lagged dependent variables as independent variables in the other equations (Johnston 1971). The "F" statistics with values of 59.45 and 26.89 in the sheep and goat inventory equations, were significant at the one percent probability level. The Theil "U" coefficients for both inventory equations were 0.029 and 0.027 confirming a good degree of adjustment between observed and predicted values (see Figures 1 and 2).

3.2. Estimates of Sheep and Goat Supply for Slaughter

The equations (2) and (4) in Table 1, were utilized to calculate the supply elasticities for slaughter of live animals. On average, the price elasticity was small with negative signs. Values were -0.18 and -0.07 for sheep and goat producers response in slaughter sales as price changes. When prices increase, the short-run supply of animals for slaughter falls and prices rise further. These results confirm the ones found in other studies made in Latin America by Gutiérrez (1982), Lattimore and Schuh (1979), Yver (1971), Nores (1973), and Barros (n.d.); and in the United States by Ospina and Shumway (1982), and Reutlinger (1966). It should be noted that these studies serve as a reference only, because of different situations, models used and different species studied.

The coefficient of inventories (IO_t and IC_t) used as variables in the supply function for slaughter of sheep and goats had negative signs showing that animal inventories and supply for slaughter interact inversely, confirming the hypothesis. Increasing animal inventories by 1% ceteris paribus, results in a reduction of goats supplied for slaughter by 0.91% and a reduction of sheep supplied for slaughter of 1.16%.

The coefficients for lagged inventories (IC_{t-1} and IO_{t-1}) for goats and sheep, respectively, are 0.13 and 0.15. These are consistent with the theoretical model, and means that a one unit increase in the lagged inventories, ceteris paribus, will increase the supply for slaughter in the current period by the actual values of the coefficients multiplied by the inventory numbers. Positive coefficients of the time trend variable (T), with values of 3.666 and 3.198 for sheep and goats respectively, are due to a decrease in animal inventories caused by adverse weather conditions and by other variables omitted in the model (i.e., credit and technology).

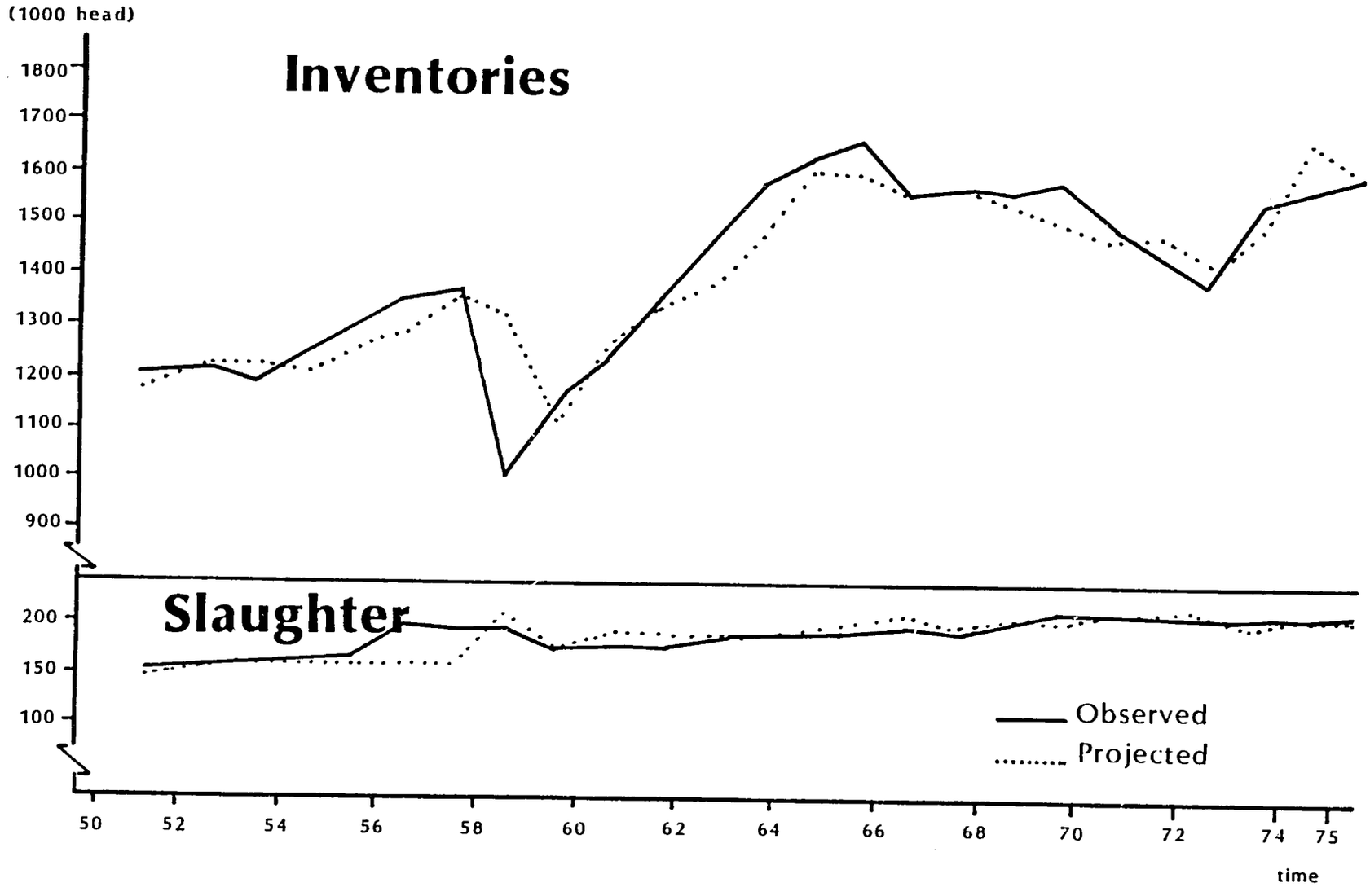

Figure 1. Comparison of observed vs projected goat inventories and slaughter supply, 1950-1975.

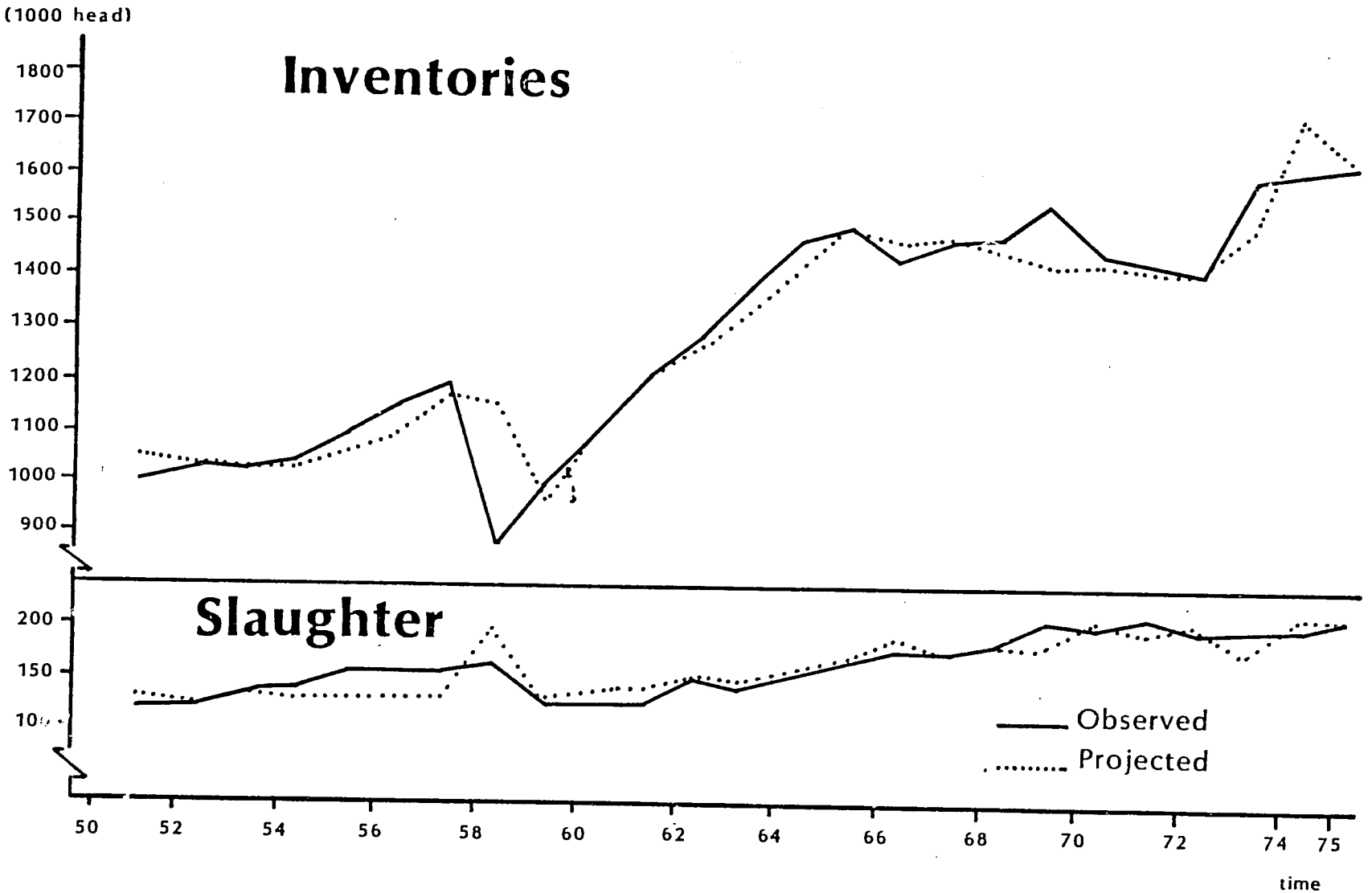

Figure 2. Comparison of observed vs projected sheep inventories and slaughter supply, 1950-1975.

The "F" statistics for both sheep and goat equations were significant at the one percent level of probability with values of 23.89 and 19.86. The "d" statistics of 1.47 and 1.10 fall into the non-conclusive region for the test of serial correlation of the residuals. The Theil "U" coefficients of 0.042 and 0.036 showed a good adjustment between current and observed values from the model. The inventory and supply for slaughter projections, as well as the actual values are presented in Figures 1 and 2 for both species.

4. CONCLUSIONS

It is important to note in this study that the statistical results are similar for both the sheep and goat models. The sheep and goat inventories were formulated in terms of prices (PO_t, PC_t), climatic conditions (W_t), and animal inventories in the previous year (IO_{t-1}, IC_{t-1}), and the results obtained for both species were similar, especially the coefficients for climatic influence and lagged inventories. This is not surprising due to the similar production structure and prices received by producers of sheep and goats in the producer regions in Ceará.

The supply equations were formulated as desired adjustments of producers inventories, which were a function of their own prices. The coefficients in equations (2) and (4) were similar and statistically significant, particularly the time trend (T) and the lagged inventory variable, which is a function of weather conditions and prices in the previous period.

An important observation is that supply elasticities for slaughter of animals in both species are negative, indicating that sheep and goat producers in Ceará respond negatively to short-run price increases.

Adjustment of inventories and supply for slaughter in response to prices have minor importance, however. The critical economic factor is probably producers ability to adjust their production conditions to avoid selling animals during dry periods when prices are falling.

Two points should be noted in this study. First, the inventory and supply equations did not use stratification of animals by sex and age, resulting in an aggregation problem. Second, the price elasticity results are related to the whole herd without discrimination by sex and age which are important determinants in the supply function, as presented in other studies cited. In these studies, there was a tendency to decrease male inventories and to increase the reproductive herd in the face of short-run price increases.

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Appendix Table 1. Data on Prices by Species, Price Index, and Climatic Variables for Statistical Estimation

Year	Real Price[a] Goat Index 1977 = 100 Cr/head	Real Price[a] Sheep Index 1977 = 100 Cr/head	Price Index[b] 1977 = 100 %	Climatic[c] Variable mm
1950	68.18	68.18	0.088	342.27
1951	65.42	65.42	0.107	86.92
1952	69.46	78.26	0.115	77.63
1953	68.18	68.18	0.132	81.68
1954	59.52	65.47	0.168	102.37
1955	60.00	65.00	0.200	179.57
1956	68.37	72.64	0.234	145.80
1957	67.41	78.65	0.267	237.63
1958	72.84	86.09	0.322	17.78
1959	72.11	84.13	0.416	93.02
1960	87.52	94.97	0.537	237.65
1961	95.10	108.69	0.736	297.39
1962	107.02	122.43	1.168	143.68
1963	95.50	112.87	1.958	316.58
1964	114.20	132.70	3.730	455.63
1965	131.28	151.28	5.850	272.73
1966	129.27	143.38	8.076	96.66
1967	117.66	135.81	10.360	348.55
1968	107.71	122.40	12.867	265.47
1969	101.08	113.85	15.502	187.01
1970	98.92	109.24	18.600	61.49
1971	110.20	121.68	22.377	183.82
1972	124.00	136.92	26.248	97.12
1973	149.16	162.09	30.161	323.80
1974	151.74	173.67	38.814	722.80
1975	163.43	180.90	49.633	268.41
Média	98.17	109.80	----	217.05

[a]Banco do Nordeste do Brasil 1977, p. 213, 205.
[b]Fundaçao Getúlio Vargas, 1979.
[c]Neto de Souza, J. 1981, p. 55-6.

Appendix Table 2. Data on Total Population and Slaughter by Species Used for Statistical Estimates

Year	Goat[a] Population	Sheep[a] Population	Goat[a] Slaughter	Sheep[a] Slaughter
	----------000 head----------			
1950	1.161	1.051	141	105
1951	1.210	1.003	160	121
1952	1.221	1.027	156	123
1953	1.202	1.019	169	135
1954	1.241	1.041	172	141
1955	1.301	1.095	189	152
1956	1.353	1.154	203	155
1957	1.382	1.193	195	154
1958	1.009	859	203	164
1959	1.160	985	155	124
1960	1.244	1.095	158	124
1961	1.363	1.203	161	127
1962	1.451	1.272	183	147
1963	1.565	1.379	182	142
1964	1.626	1.465	193	154
1965	1.662	1.507	195	163
1966	1.556	1.444	203	174
1967	1.577	1.473	197	173
1968	1.566	1.481	216	189
1969	1.585	1.550	237	204
1970	1.501	1.450	239	200
1971	1.443	1.432	239	208
1972	1.386	1.415	228	196
1973	1.544	1.607	231	199
1974	1.570	1.626	234	203
1975	1.596	1.645	238	207
Média	1.402	1.287	195	161

[a]Banco do Nordeste do Brasil 1977, p. 208, 202, 211 e 205.