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of

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Gustavo A. Nores

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

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As is customary, I hasten to say that all the errors and shortcomings of this study are, of course, my own responsibility.

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ABSTRACT

Nores, Gustavo A., M.S., Purdue University, June 1969. An Econometric Model of the Argentine Beef-Cattle Economy. Major Professor: Joseph Havlicek, Jr.

The economic problem was stated as the need for an explanation of price fluctuations at the farm level during the period 1935-1966, on the basis of economic reasoning and empirical evidence. It was hypothesized that the nature of both aggregate derived demand and slaughter supply was responsible for such price fluctuations, and that both domestic demand and demand for exports played an active role in the price formation mechanism. It was further hypothesized that cattle farmers had a different response to current market price in terms of the quantity marketed of each category of animals.

The main objective of the study was to identify and quantify the annual structure of the Argentine cattle-beef economy, for the period 1935-1966, in a degree sufficient to provide a framework for the analysis of the causes of price fluctuations. Specific objectives were: (1) to fit and derive supply and demand relationships at different levels of the marketing channel of beef; (2) to determine the interrelationships between the domestic and the international market for Argentine beef; (3) to evaluate the impact on prices and quantities at the farm level of changes in certain variables and parameters at the retail level, the international market and exchange-rate policy; and (4) to analyze the findings in terms of the economic hypotheses and in the light of policy

implications.

The structural model consists of eight behavioral equations describing domestic and foreign demand, marketing and export-packers groups' behavior, slaughter supply of steers and yearly steers, slaughter supply of cows, heifers, bulls and calves, and an average weight relation. In addition, two identities were specified: per-capita to total consumption and foreign-domestic price transformation identities. A farm market clearing condition closes the system of eleven equations in eleven endogenous variables.

Two-stage least-squares technique was used to estimate the structural parameters on the basis of secondary data, annual data for the period 1935-1966.

The low values obtained for the price elasticities of aggregate demand and slaughter supply at the farm level, and the relative large coefficients of cross elasticities found for the slaughter supply and demand for export give empirical support to the main hypothesis. In particular, total slaughter supply is estimated as being highly inelastic with respect to current price, thus, it is an indication that shifts of aggregate demand at the farm level would result in wide price fluctuations. In addition, if a shift in demand causes an increase (decrease) in price, such higher (lower) price would command a lower (higher) volume of slaughter in the next period and consequently would lead to a still larger increase (decrease) in price.

The value obtained for the elasticity of export demand with respect to exchange rate indicates that the latter is a powerful shifter of demand for exports thus indicating, as it was hypothesized, that this function plays an active role in the price formation mechanism. It is

concluded that exports of beef should not be considered just as "the residual over and above domestic consumption" as in an accounting framework but, from an economic viewpoint, should be considered as an important component of aggregate demand at the farm level.

The hypothesis that cattle farmers have a different response to current market price in terms of the quantity marketed of each category of animals, was not rejected on the basis of the empirical estimates obtained.

CHAPTER I
THE PROBLEM

Introduction

From an economic point of view, the agricultural sector in Argentina is considered important because it represents 13% of GNP, satisfies domestic consumption, accounts for 90% of exports and provides inputs to the industrial sector. The volume of production of this sector fluctuated during the last three decades, but fluctuations were sharper within the sector itself. Gross agricultural product increased only 14% between 1935-39 and 1960-63. The gross product of the livestock activity increased 25% while that of the crop activities increased only 4% during this same period. Both types of activities seem to be to some extent competing for land. In the main productive region (Region Pampeana) the area devoted to crops decreased from 27% to 21% of the total farming area, while for the same period the area devoted to livestock farming increased from 73% to 79%.[1/] It has been said that the overall characteristic was of a "poor performance of the export oriented part of agriculture" while an increase "in output of domestically consumed products".[2/]

[1/] OECEI, "Economia Agropecuaria Argentina - Problemas y Soluciones", Tomo I, p. 81, 1964. For more detailed information on the relative importance of cattle, some of the production and marketing problems, and the role of prices, see: Fienup, Darrell F., Brannon, R. M. and Fender, R. A., Argentina: The Sleeping Giant: A Study of the Problems and Opportunities of its Agriculture, The Ford Foundation, 1967, pp. 38-42, 76-85, 119-125, 250-256.

[2/] Reca, Lucio G., "The Price and Production Duality Within Argentine Agriculture, 1923-1965", unpublished Ph.D. dissertation, University of Chicago, 1967, p. 2.

Exports of livestock products decreased from 38% to 26% of the total value of production between 1934-39 and 1958-62.[3/] This study focuses on the beef-cattle economy which represented during the period 1935-1966 about 60% of gross livestock product. In the last decade one-fourth of the volume of beef production was exported accounting for more than 20% of the total value of exports.

The Problem

Real income of beef producers showed very sharp fluctuations during the last three decades. These fluctuations seem to be highly correlated with those of the real price received by farmers.[4/] Sharply fluctuating prices tend to discourage potential investment in the sector,[5/] and seem to be the cause as well as the consequence of a fluctuating production. Prices may fluctuate not only because of shifts in market supply (slaughter) but also because of shifts in market demand from either domestic demand or demand for exports, or both.

Different policies have been applied during the last three decades to the beef-cattle economy; many times contradictory ones.[6/] Explicit or implicit objectives have not been stable through time nor consistent with the general economic policy.

[3/] Sigaut, Lorenzo Juan, Desarrollo Agropecuario y Proceso de Industrializacion en la Economia Argentina, Buenos Aires, OECEI, 1964, pp. 76-82.

[4/] Banco Ganadero Argentino, "Mercados y Precios del Ganado Vacuno", 1966, pp. 6-18.

[5/] The effects of price uncertainty on production were well pointed out by Ernesto S. Liboreiro in his paper: "The Possible Uffects of Price Uncertainty on Agriculture Beef Production", unpublished Research Paper, submitted to the College of Agriculture, Michigan State University, June 1968.

[6/] Kohout, J. C., "A Study of the Factors Affecting the Supply of Beef Cattle in Argentina", unpublished paper presented at PPEA Seminar, Boulder, Colorado, 1966.

Two main goals have been suggested:[7/] a) for the short run, production stabilization as a means of farm income and price stabilization; and b) for the long run, increase of the value of cattle and beef exports. But, as long as demand at the farm level fluctuates, production stabilization may reduce but not eliminate price and income fluctuations. More stable prices may encourage potential investment and may permit a more productive allocation of resources. More stable income may give security to farmers but a price stabilization policy may or may not maximize their total revenue. Professor Sheperd commets:[8/] "...the effect of price stabilization programs on total revenue from the sale of the crop depends primarily upon the curvature of the demand curve for the crop and secondarily upon its elasticity...". The goodness of stabilization is generally accepted but has not been tested for the Argentine beef-cattle economy. To answer this question some knowledge about the shape of the farm-level demand curve is needed. However, there are other reasons that make production and price stabilization desirable. One of the main requirements to have access to foreign markets is regularity of supplies. As has been stressed by Herrmann and Branson,[9/] undependable supplies may lead to the

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[7/] Banco Ganadero Argentino, "Mercados y Precios del Ganado Vacuno" Buenos Aires, 1966, p. 42-43.

[8/] "If the elasticity of the demand curve is constant, but less than unit ...., a stabilization program ... would reduce total revenues. The opposite is true of demand curves with a constant elasticity greater than unity. If demand curve for the crop is less concave from above (than the unitary constant elasticity one) the stabilization of that crop will increase total revenues. If, on the other hand, the demand curve is more concave (more curved) than the standard curve (unitary elasticity,) stabilization would decrease total revenues", (Italics are mine). Shepherd, Geoffrey S., Agricultural Price Analysis, Ames, Iowa, Iowa State University Press, 5th Edition, pp. 189-191.

[9/] Herrmann, L. F. and R. E. Branson, extensively discuss the advantages of product and price stabilization in "A Program for Stabilizing Argentine Beef Exports". A Special Report to CAFADE and to USAID/Argentina, Buenos Aires, Argentina 1962.

raising of barriers to entry, thus limiting the possibility of obtaining export earnings.

As in most developing countries, in Argentina export earnings are considered a scarce and vital resource. Very often the balance of payment is regarded as the bottle-neck that stops development. To increase the value of beef exports is an important goal in Argentina, but the increasing trend in domestic consumption is limiting the possibility of achieving it. Different policies have been applied towards achieving this objective, particularly since 1955. Some policies have tried to reduce domestic consumption, and some have tried to increase production as a means of increasing exports. The exchange market has been one of the most frequently used instruments as a means of achieving such targets. Different policies, running all the way from full control to the free market were applied. The heavy inflationary process suffered by the economy in the last two decades has motivated, from time to time, successive devaluations of the "peso".[10/] These devaluations were in most cases accompanied by changes in the export-tax structures. Sometimes the objectives were partially met, but the overall resultan. has not been of a permanent increase in beef exports.

A whole arsenal of policies has been instrumented without clear and consistent goals or reliable knowledge about the particular nature of supply and demand at different levels of the cattle-beef market. The farm level demand may not necessarily be parallel or have the same elasticity as the one at the retail level. There are some estimates of

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[10/] See: Diaz Alejandro, Carlos F., Exchange Rate Devaluation in a Semi-Industrialized Country - The Experience of Argentina 1951-1961, The M.I.T. Press, U.S.A., 1965.

retail demand elasticities, but as Diehl and Wallace[11/] point out: "... retail elasticities tell us little about farm income effects of policy changes unless farm level elasticities are about the same as retail elasticities..."

Whether the marketing group reflects gains and losses back to farmers is a question that needs to be answered. To maximize total revenue at the retail and export markets does not imply that total revenue is also maximized at the farm level. Consumers' demand is relevant at the retail level and international demand for Argentine beef is of interest with respect to the export market, but a derived demand is the relevant one at the farm level.

Clear and consistent goals, and reliable knowledge about the structure of the cattle-beef economy are prerequisites for policy making. This study will deal with the structure of the cattle-beef economy.

Why have prices fluctuated so radically during the last three decades? What are the forces operating in the price-making mechanism? Can movements in prices be explained by movements in demand and/or supply? What are the characteristics of supply and demand relationships in the cattle-beef economy of Argentina? The identification of demand and supply at different levels of the market, specifically the identification of the forces operating behind them, constitutes our main objective.

[11/] Diehl, W. D. and Wallace, T. C., "Elasticities of Derived Demand for Hogs", unpublished paper based on unpublished M.S. dissertation, "Analysis of Derived Demand for Hogs", by William David Diehl, Department of Agricultural Economics, North Carolina State College of the University of North Carolina, 1965.

Literature Review

In order to put this study into perspective, several previous studies are briefly reviewed in this section. The specific studies reviewed were selected because they are concerned either with domestic demand for beef, or because they deal with the domestic supply of cattle for slaughter, or both.

Domestic demand for beef has been subjected to research by Guadagni[12/] (1964) and Guadagni and Petrecolla[13/] (1965). In the first of these studies Guadagni estimated a demand function of constant elasticity where the dependent variable was per-capita beef consumption and the explanatory variables were retail price of beef, price of pork, price of lamb, per-capita income and one year lagged per-capita consumption. The introduction of the latter predetermined variable as a stabilizer of demand, improved the coefficient of correlation (Pearsonian) from .60 to .70 with a partial coefficient of correlation for this variable (holding the others constant) of .45. The coefficient of this variable and the retail price of beef were statistically significant from zero at the .01 level; however, the coefficient of the income variable is significantly different from zero only at the .20 level, while the coefficients of the prices of pork and lamb are not significantly different from zero at the .25 level. The author concludes:

[12/] Guadagni, A. A., "Estudio Econometrico del Consumo de Carne Vacuna en Argentina en el Periodo 1914-1959", Desarrollo Economico, Vol. 3, No. 4, pp. 517-533, January-March 1964.

[13/] Guadagni, A. A., and Petrecolla, A., "La Funcion de Demanda de la Carne Vacuna en la Argentina en el Periodo 1935-1961", El Trimestre Economico, April-June 1965.

"...the high consumption of beef in Argentina makes it inelastic to changes in per-capita income. Also regarding its own price the lowest elasticity (among a group of countries) corresponds to Argentina, the cause for it being the lack of true substitutes for beef. ....It is suggested that a policy of price increases to discourage domestic beef consumption is of little scope."

The study done by Guadagni and Petrecolla is a continuation of the one just discussed. Its objective was to consider broader sets of substitutes for beef, and to analyze the effects of income distribution on beef consumption. A demand function of constant elasticity was fitted and because of problems of multicollinearity the first differences of the original values of the variables were used. The elasticity of consumption with respect to population was not significantly different than one at the .05 level; therefore, the authors concluded that it is permissible to estimate the demand function for beef in per-capita terms. The cross price elasticity beef-other foods was estimated negative but non significantly different from zero. The estimated income elasticity for wage earners was smaller than the income elasticity of non-wage earners thus contradicting theory and suggesting that an "expenditure-elasticity", where different qualities have weight, instead of the "quantity elasticity" merits some consideration.[14/]

Estimates of short and long run elasticities were obtained by means of a "Nerlovian model" of distributed lags. The estimated adjustment period was 1.34 years, and a relatively large elasticity of adjustment was found (γ = .893). Price and total income elasticities were smaller than one but significantly different from zero at the .0005 and .005 levels respectively. The authors conclude that demand for beef is inelastic with

[14/] When income changes, consumers may switch to higher (lower) quality cuts but still maintain the volume of consumption; some cuts of beef may be considered inferior goods.

respect to price and income for the period under study. The results of a posterior research[15/] confirm the order of magnitude of the price and income elasticities found by Guadagni and Petrecolla.

Diaz Alejandro[16/] (1964), Iver[17/] (1964), and Reca[18/] (1967) have engaged in research dealing with the domestic supply of beef. Diaz Alejandro focused attention on the 1944-59 period during which time quoting his own words:

> "... the government set maximum prices, which in effect substituted the market demand for beef for an artificial schedule that was perfectly elastic in the relevant range. Thus, for those years an estimate can be made on the basis of the observed prices and quantities of the supply schedule for beef without taking the true market demand schedule into account."[19/]

The author develops a theoretical argument supporting a positive price elasticity of supply but a negative price-elasticity of slaughter. A linear model in the first difference of the variables was used to subject such a hypothesis to an empirical test, and the findings tend to support it. Diaz Alejandro comments:

[15/] Dieguez, Hector L., "Un Ejercicio Econometrico en torno a los Problemas de Multicolinearidad y Autocorrelacion", (Problems of Multicollinearity and Autocorrelation: An Econometric Exercise), Staff Paper No. 48, Centro de Investigaciones Economicas, Instituto Torcuato Di Tella, Buenos Aires, 1967. This paper presents a reconsideration of the statistical procedures used in Guadagni and Petrecolla's paper op. cit. [13/] above.

[16/] Diaz Alejandro, Carlos F., op. cit., pp. 79-87.

[17/] Iver, Raul E., "La Oferta de Ganado Bovino en Argentina", Desarrollo Economico, Buenos Aires, Vol. 5, Tomo I., no. 17-18-19, pp. 211-230, Abril-Diciembre 1965.

[18/] Reca, Lucio G., op. cit., pp. 6-8, 58-66 and 128-134.

[19/] Diaz Alejandro, Carlos F., op. cit., pp. 79-80.

> "It may be concluded that a devaluation can expect little help in the short run from the response of beef production; not only will available supplies fail to expand in the short run but they are actually likely to decrease."20/

In the second of the studies mentioned above (see 17/) Iver develops a theoretical model of Nerlovian style where desired production is a function of expected relative prices which are revised according to an elasticity of expectation. Observed production relates to desired production in a scheme similar to Friedman's "permanent income hypothesis" where a component called "transitory production" makes up for the difference (observed production = desired production + transitory production). Transitory production is assumed to be a function of the initial stock of cattle, climatic conditions and random elements, but not of prices. The author does not subject this model to an empirical test, but in the search for the necessary data to carry it out, he develops a model to estimate the inventory of beef-cattle for inter-census years. Basically, the procedure consists of determining an average net calving percentage by using the information on inventory level for census years and on slaughter for inter and census years; once the average net calving percentage is determined, it is used together with the information on slaughter to reconstruct the inventory figures.

In his study of supply, Reca follows a procedure similar to the one suggested by Iver to reconstruct the inventory figures for intercensus years. The desired size of the herd is hypothesized to be a function of expected relative price of beef and weather conditions in the previous year. Observed adjustment of the size of the herd or change in inventory,

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20/ Diaz Alejandro, Carlos F., op. cit., p. 84.

production minus slaughter, is assumed to be a linear function of the desired adjustment in a Nerlovian framework. Production is assumed to be a linear function of the size of the herd at the beginning of the period, being the slope coefficient the computed average rate of growth of the cattle herd for the intercensus period. In other words, production depends on the size and average rate of growth of the herd.

The period considered by Reca (1923-65) is broken into two parts based on census years, 1923-47 and 1947-65, and results differ for the two periods. The model of price expectation (also of Nerlovian style)[21/] considers four alternative forms involving from one to seven past annual relative prices weighted in a geometrically declining way. The author, comparing the results of both sub-periods comments:

> "In the years 1923-47 the best fit is given by the expected price formed by seven annual prices, while in 1947-65 the best fit results from an expected price that includes only one past price. ...The shift from a price horizon of seven years to another of only one year is consistent with the price policies toward agriculture characteristic of both periods. While in 1923-47 product prices change basically as the result of market forces, for most of 1945-65, changes in product prices were largely the creature of policy..."[22/]

The coefficient of adjustment estimated for the second period is smaller than the one estimated for the first one; also, the elasticity of the desired size of the herd with respect to price diminished from .38 to .26 between the first and second period.

Price of beef cattle relative to grains and also the size of the herd were, in general, larger for the period 1947-65 compared to the

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[21/] Nerlove, Marc, "Distributed Lag and Demand Analysis for Agricultural and Other Commodities", Agricultural Handbook No. 141, U.S.D.A. Agricultural Marketing Service, Washington, June 1958, pp. 23-25.

[22/] Reca, Lucio G., op. cit., pp. 62 and 65.

period 1923-47. This suggests two possible explanations of the above mentioned smaller price elasticity of the desired size of the herd found by Reca for the latest period: (1) the longrun supply curve did change (slope and/or intercept) between 1923-47 and 1947-65, or (2) the change in elasticity comes about because of a movement along a non-constant elasticity supply curve. If the latter is the case, increases in production may be achieved by shifting the production function (i.e., by shifting the supply curve), rather than by increasing relative prices even more.

The above reviewed studies have focused attention on some partial and assumed independent aspects of the cattle-beef economy. A more ambitious endeavor is the research done by Otrera[23/] (1966) where both, domestic demand and domestic supply were considered in a simultaneous system of equations together with demand for exports. The general objective of the study was:

> "...to evaluate quantitatively those factors which appear to generate fluctuations in the quantity and price of beef produced and sold. ....Since beef exports are generally considered to be a surplus over and above domestic consumption, special emphasis will be placed upon developing an analytical tool to estimate the beef export potential."[24/]

An inventory relationship was estimated independently of the system. The inventory level was expressed as a function of the previous year level, lagged prices of beef and grains, previous range conditions and inflation rate.

[23/] Otrera, Wylian Rolando, "An Econometric Model for Analyzing Argentine Beef Export Potentials", unpublished Ph.D. dissertation, Texas A&M University, May 1966.

[24/] Otrera, Wylian, R., op. cit., p. 12.

Within the simultaneous system, production of beef-cattle (slaughter plus change in inventory) was estimated as a function of farm price of beef, time (proxy for technological improvements), rainfall conditions during the previous year (proxy for pasture conditions) and inventory level at the beginning of the period. The supply of dressed beef was divided into two components: (1) number of cattle slaughtered, and (2) average weight per animal. The average weight was considered a function of farm price of beef, rainfall conditions of the previous year and time. The number of cattle slaughtered was analyzed as a function of production, farm price of beef, time, and previous farm level prices of beef and grains.

The demand of beef-cattle at the farm level was postulated as the farm price of beef being a function of the number of beef-cattle slaughtered, the retail price, and the beef bought by meat packing companies for export. The domestic retail demand was postulated as the retail price of beef being a function of the total supply of dressed beef, total domestic consumption of beef, time, per-capita national income and population.

In the demand-for-export equation, the quantity of beef bought by packing houses for export is considered as a function of total supply of dressed beef, of the retail price of beef and of the Argentine population. This implies the consideration of exports as a residual over and above domestic consumption where no role is given (neither active nor passive) to the price paid in foreign markets for the quantities exported.[25/]

The complete system submitted to estimation by Otrera consists of six equations (supply of beef-cattle, demand of beef-cattle, average

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[25/] op. cit., pp. 41-43, 46, 103, 124.

weight of beef-cattle, number of beef-cattle slaughtered, domestic demand at the retail level and demand for export), one identity (total production of dressed beef = number of beef-cattle slaughtered times average weight) and a market clearing condition (production of dressed beef = consumption plus exports). The equations were formulated in linear additive form and three different procedures were used (limited - information single equation - LISE or LVR - Two Stage Least Squares - TSLS-and Ordinary Least Squares - OLS) to estimate the parameters. For every equation the estimates are compared on the basis of statistical significance and possible economic interpretation. The inventory relationship was estimated independently of the system.

In general the estimated coefficients were smaller when allowing for simultaneity than when estimating the equations independently by applying OLS. Estimates of elasticities were also smaller when simultaneity was considered. Most of the estimated coefficients had the sign postulated by the author; only three did not match the a priori sign.[26/]

Given that two of the above reviewed studies deal with retail domestic demand, three of them deal with farm level supply, and the last one deals simultaneously with both, the reader may wonder whether there is room left for further study. Even though these authors have provided answers to many of the important questions that are raised about the problems that the Argentine cattle-beef economy faces, it is still felt that not all the important questions have been answered. In particular, the

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[26/] op. cit., pp. 81, 87 and 120. The coefficients of time and rainfall conditions in the production of beef-cattle equation (supply of beef at farm level) were postulated with positive sign and estimated with negative. In the relationship involving the number of cattle slaughtered the parameter of the production variable was postulated with positive sign and estimated with negative.

question of the role of the external market in the farm level price formation mechanism is not answered by the studies reviewed. The influence of the exchange rate and export-taxation policies on export level and farm price are yet to be explained, and the feeling here is that the answer to this and related questions have strong policy implications.

Hypotheses

Considerable fluctuation in the price of cattle at the farm level may not permit an efficient allocation of resources. But price stabilization programs may not necessarily be compatible with revenue maximization goals, and maximization of the revenue of exports may not match the allocation of beef between domestic consumption and export which maximizes the farm income. Given a set of goals or targets, decisions should be made by policy and decision makers on the basis of certain knowledge about the causes of these price fluctuations. The economic problem could be stated as "the need for an explanation of these price fluctuations on the basis of economic reasoning and empirical evidence."

One possible hypothesis is that the very nature of the productive process is responsible for this, where not only the production period is longer than the observation units (the year) - which would lead to the formulation of a dynamic "cobweb effect" - but also part of production may be considered capital good (heifers may be kept as breeding stock) and capital goods may be sold as final product (cows and bulls for slaughter) which may transform a "cobweb effect" into a retractive process that has been called "super-cobweb effect".[27/] Production may be allocated

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[27/] Diaz Alejandro, Carlos F., op. cit., p. 80.

between slaughter and inventory demand for future output expansion. This allocation process between both may be influenced by price expectations if farmers are profit maximizers. The type of "super-cobweb effect" will depend on the nature of the formation process of price expectations and the elasticities of both market demand and supply in the relevant range.

A second possible hypothesis is that the very nature of the demand facing the market supply was responsible for and/or contributed to, the price fluctuations. Market demand consists of a demand for domestic consumption and a demand for exports. While the first one may have been shifting because of population increase, redistribution of income, and rural to urban migrations, the second may have been shifting back and forth because of deviations in the international demand for Argentine beef, institutional factors such as exchange policy - fixed exchange rate while domestic inflation occurred -, export tax structure, availability of shipping space (hold capacity), bilateral agreements, or restricted access to foreign markets because of protectionistic policies or other unilateral decisions.

A more general and comprehensive hypothesis is that both demand and supply forces were responsible for the price fluctuations. There are numerous different possible combinations of shapes and types of shifts of farm level market demand and supply that could yield such fluctuations. Those considered more relevant are discussed below.

There is some evidence that domestic retail demand is rather inelastic within the relevant range.[28/] If that is the case, then wide price

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[28/] The estimates obtained in the above commented studies (See 12/, 13/, and 23/) for the short run elasticity of demand vary between -.285 and -.481 and long run elasticity estimated by Guadagni and Petrecolla (see 13/) was of a value of -.533.

fluctuations may be the consequence of a shifting supply. But there is also some evidence that at least part of the international demand for Argentine beef is quite elastic;[29/] which would be reflected in the demand for export in the domestic market and the aggregate farm level demand curve may not be so inelastic.

Opinions are divided regarding the role of the external market in the price determining mechanism and the allocation process of beef between domestic and external market. The Banco Ganadero comments:

> "At first, it seems logical that prices of beef in the international market - assuming free access to the markets - are the ones that determine the volume of exports. ....Such is the opinion of some researchers. ...Others argue that the inverse relationship is the relevant one; Argentinian exports of beef would determine its price in the international market. ...This last explanation agrees with the opinion that exports are, according with the popular concensus, the surplus of slaughter above the domestic consumption. ...exports are a residual that depend directly on slaughter and domestic consumption, and indirectly on the factors that influence both, mainly retail price, income, and quantitative restrictions when they exist."[30/]

The idea that exports are a residual is not new and has been flagged many times[31/] but in this particular case, it seems to be based more on accounting rules than on economic reasoning. It is true that what is not consumed domestically is exported or vice versa (after the allocation is completed you may know one by just knowing the other and the total) but in allocating a limited amount between two demands both are relevant and taken into consideration. The fact that domestic demand absorbs a larger

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[29/] Herrman, Louis F., and Branson, Robert E. op. cit., pg. 8. These authors have estimated an average price elasticity for the British demand for Argentine beef or -2.0.

[30/] Banco Ganadero Argentino, op. cit., p. 26 (translation to English is mine).

[31/] See 25/ above.

percentage of the total slaughter does not imply that the price received for Argentine exports is not relevant in the price formation process at the farm level, neither does it suggest that these prices do not enter the allocation process between both destinies.

A simple graphical analysis of the well known price mechanism in international trade will illustrate the point. For simplicity, assume that trade takes place only between two countries (i.e., Argentina and England), in the same currency, and that transportation and other costs are negligible.[32/] Figure "A" represents the Argentine domestic market, where "ADD" stands for domestic demand, and "AMS" is the market supply curve.[33/] Figure "B" represents the British domestic market, where "BMD" stands for the market demand, and "BDS" is the domestic supply. The Argentine excess supply-demand function (AES-AED) of figure "C" is derived from figure "A" by subtracting for every price "ADD" from "AMS". Similarly, the British excess demand-supply function (BED-BES) of figure "C" is derived from figure "B" by subtracting for every price "BMD" from "BDS".

Under the above stated assumptions, price $\bar{p}$ would be the equilibrium price and Argentina would export to England the quantity q_1q_2. As the reader can see, these excess functions (AES-AED and BED-BES) were fitted as residuals but each one comes from a different market. The intersection

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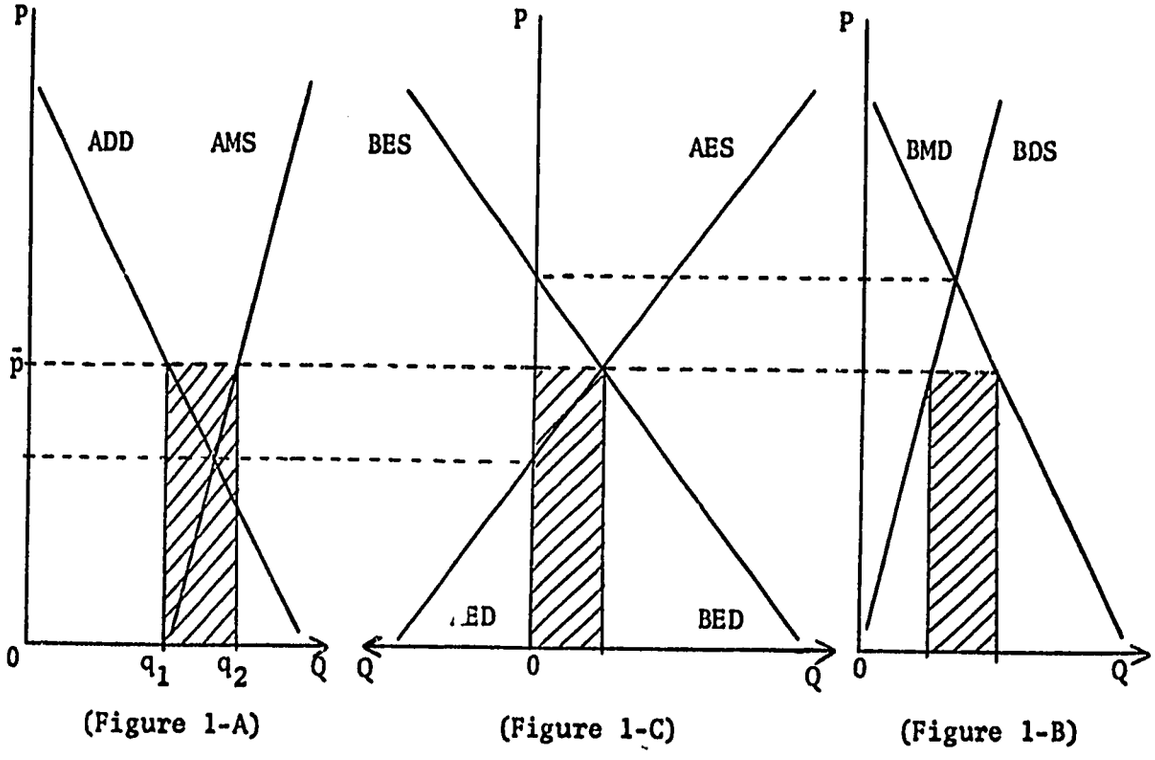
[32/] If any or all of these assumptions are dropped the same reasoning may be applied without loss of generality.

[33/] This market supply function may have either positive or negative slope without loss of generality as long as $\frac{\partial AMS}{\partial P} > \frac{\partial ADD}{\partial P}$; if $\frac{\partial AMS}{\partial P} = \frac{\partial ADD}{\partial P}$ no trade takes place; and if $\frac{\partial AMS}{\partial P} < \frac{\partial ADD}{\partial P}$ the direction of the trade changes, because what before was excess supply is now excess demand and vice versa. A similar reasoning is applicable to the British supply function.



(Figure 1-A) (Figure 1-C) (Figure 1-B)

Figure 1. An Example of Excess Supply and Demand Functions

of these two excess functions will determine the volume of exports (imports) and the equilibrium price. Thus, it can be stated that exports are not "a residual over and above domestic consumption" only, there is something more; the excess international demand function is as important as the excess domestic supply function in the allocation and price determination process. Whether the government intervention in the cattle-beef economy off-sets the active role of the international demand is another question. It is felt that this is not the case.

It might seem rational that export packers consider the price paid for their exports, the current exchange rate, and export taxes (retenciones) when deciding about the volume of their exports. It appears also that the price received by Argentine beef exports is somewhat endogenous to the system when considering the market supply and demand functions for it at the international market. If this is the case, price fluctuations at the farm level may be not only the consequence of a fluctuating market supply and domestic demand but also the consequence of a fluctuating international demand for Argentine beef and changes in the exchange rate and export taxes.

If the foreign demand for Argentine beef is somewhat elastic, and such elasticity is reflected in the derived demand for exports at the farm level, the aggregation with the derived domestic demand would yield a curve with an elasticity - for the relevant range - larger than that of the derived demand for domestic consumption. If this aggregate demand at the farm level is not so inelastic, but more or less stable, wide fluctuating prices could be caused by a widely shifting supply or by shifts of a negative sloping market supply function (short-run slaughter

function).[34] A third alternative would be negatively correlated shifts of supply and demand, and the possible combinations do not end here. In summary, it is hypothesized that the nature of both demand and supply was responsible for such price fluctuations, and that both domestic demand and demand for exports enter the price formation process confronting the relevant market supply functions of beef-cattle.

Objectives

The main objective of this study is to identify and quantify the annual structure of the cattle-beef economy of Argentina. Specific objectives are: 1) to formulate and estimate supply and demand relationships at different levels of the marketing channel for beef; 2) to identify and evaluate the interrelationships between the domestic and the international market for Argentine beef; 3) to evaluate the impact on prices and quantities at the farm level of changes in certain variables and parameters at the retail level, in the international market and of exchange rate policies; and 4) to analyze the findings in terms of the stability of equilibrium and in light of their policy implications.

The economic model representing the annual structure of the Argentine cattle-beef economy is developed in Chapter II, with a paralleling statistical model being discussed in Chapter III. The estimates and empirical results are presented and analyzed in Chapter IV. Chapter V deals with the computation and evaluation of the elasticities of aggregate demand and market supply of beef at the farm level, their implications in terms of the stability of equilibrium, and with the testing of the economic

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[34] See Diaz Alejandro, op. cit., pp. 83-84, and Reca, op. cit., pp. 61-66.

hypothesis developed in this chapter. Finally, a summary of this study, the conclusions obtained and the economic policy implications of the findings are presented in Chapter VI.

CHAPTER II
ECONOMIC MODEL

In the economic model representing the annual structure of the Argentine cattle-beef economy, five groups or sectors are considered: domestic consumers, foreign consumers, domestic intermediaries, export packers, and producers. This model is developed in three phases. In the first phase, aggregate relationships are postulated on the basis of the variables present in the behavioral relationships of decision units in each of the five sectors. In the second phase the complete structural model based on postulated aggregate relationships is developed. Finally, by using successive substitution some of the endogenous variables of the structural system are eliminated and thus, a reduced model is obtained.

In developing the economic model, pure competition is assumed at different levels of the market and therefore, it is assumed that neither producers, consumers, nor intermediaries individually influence output or input prices. Producers, intermediaries and export packers are assumed to maximize profits subject to their production function. The product is assumed to be essentially homogeneous.[1/] Domestic consumers

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[1/] The word homogeneous is used here to mean two things: a) homogeneous quality-wise overtime, and b) homogeneous price-wise overtime. Beef at the retail market is not a homogeneous product in the quality sense; different cuts do not look the same to the consumer. However, if the price of each cut of beef changes in the same direction and proportion than the other cuts included under the general name of "beef", such a group of commodities (called beef in this case) behaves just as if it were a single commodity. It is also in this sense the product is assumed to be essentially homogeneous. This has been called (continued next page)

are assumed to have an invariant preference scale (an invariant set of indifference curves) for the sample period and to individually maximize their satisfaction subject to their budget constraint. A similar set of assumptions is made about foreign consumers. More specific assumptions will be formulated throughout the development of the model.

First Phase: Aggregate Relationships

In this phase trade is assumed to take place at three separate but interdependent markets: the retail market, the external market and the farm level market. In the retail market two aggregate behavioral relationships are of concern: the domestic retail demand and the marketing group's supply; a retail market clearing condition would partially close the system. In the external market two aggregate behavioral relationships are of interest: the international demand for Argentine beef, and the export packers' supply; a transformation identity allows the expression of both supply and demand in the same currency, and an external market clearing condition would partially close the system. Finally, five aggregate behavioral relationships are relevant at the farm level: the marketing group's demand, the export packers' demand, the farm level slaughter supply of steers and yearly steers, the farm level slaughter supply of cows, heifers, bulls and calves, and the average weight relationship; a farm market clearing condition closes the system. The theoretical development of each relationship is considered separately.

1/ (continued)
"the composite good theorem" and demonstrated mathematically by J. R. Hicks in his book: Value and Capital. Oxford University Press, Amen House, London, 1965 2nd Edition, pp. 312-313; and Samuelson, P. A., Foundations of Economic Analysis, Chapter VI; Composity Commodities, Atheneum, N.Y., 1965, pp. 141-143.

Domestic Retail Demand

The theory of consumer equilibrium has been well developed and can be applied directly to the demand for beef at the retail level. Assuming a unique preference scale for the individual and that he maximizes his utility subject to his budget constraint, it is possible to derive from the first order condition for utility maximization a set of equations called "individual demand functions". For each permissible set of prices and budget (or money holding) these functions relate the quantity of each good that the consumer will purchase in equilibrium at those prices given his budget constraint (or money holding). The functions are single-valued and homogeneous of degree zero in income and prices. Theoretically, the prices of all goods that enter the preference functions enter the individual demand function; however, when dealing with partial equilibrium analysis it seems reasonable, from a practical point of view, to consider just closely related substitutes and complements. If a commodity is exclusively sold to consumers, the horizontal summation of the individual demand functions is the market demand function for the commodity in question. Every individual's income enters such a function, not as an element in a sum but as a separate variable,[2/] and variations in an individual's income affect the market demand through its effect on the individual's demand function.

[2/] Lloyd, Cliff, Microeconomic Analysis, Richard D. Irwin, Inc., Homewood Illinois, 1967, pp. 30, 77-78.

Hicks, J. R., Value and Capital, Oxford University Press, Amen House, London, 2nd Edition, 1965, pp. 34-35.

Henderson, J. M. and Quant, R. E., Microeconomic Theory - A Mathematical Approach, McGraw-Hill Book Company, New York, 1958, pp. 87-89.

This market demand function as suggested by traditional microeconomic theory can be represented as follows:

$$Q_t^d = f\ (P_t^1,\ P_t^2,\ \ldots,\ P_t^m,\ y_t^1,\ y_t^2,\ \ldots,\ y_t^n)$$

where Q_t^d is the market quantity demanded for the product in question during period t,

P_t^i is the market price of $i^{\underline{th}}$ product for period t, and

y_t^j is the income of the $j^{\underline{th}}$ consumer for the period t.

Traditional microeconomic theory stops here, and therefore, when time series data are used to estimate the market demand function for a commodity two problems have to be faced: (1) unless the observed community were very small, it is not feasible to observe the income of each and every consumer throughout the time period considered and (2) the number of income variables entering into such a market demand function is not constant if population varies throughout the sample period. Some information about those variables is available: the size of the population (at a given point in time) and the aggregate value of income; by combining this information the mean value or per-capita income can be obtained. There are alternative ways of incorporating such information when trying to fit a market demand function, and specific assumptions are pertinent to each case. Only two of such alternatives are discussed.

It is assumed that (a) whatever the consumers' preferences (indifference maps) are, they do not change for the sample period, (b) consumers individually maximize their utility subject to their budget constraint, and (c) the product is essentially homogeneous (see footnote 1). In addition, (d) constancy in the distribution of income is assumed in the sense

that whenever aggregate income of a given group of consumers changes, such a change is made up of a proportional change in the income of every consumer of the group; that is:

$$Y = \sum_{i=1}^{n} y_i$$

$$\frac{dy^i}{y^i} = \frac{dY}{Y}; \quad i = 1, 2, \ldots, n \text{ consumers.}$$

where Y is the aggregate income, and

y^i is the income of the ith individual; $i = 1, 2, \ldots, n$

Assumption (d) stipulates that each individual's income maintains its proportionality with aggregate income throughout the sample period. If assumption (d) holds, either per-capita or aggregate income could be used in the market demand function to represent the income constraint of individual consumers, given that per-capita income is in this case a fixed transformation of aggregate income.[3/]

If the number of consumers does not remain constant during the sample period, per-capita income will not account for the change in consumption due to variations in population; and aggregate demand will fail to distinguish between changes in the individual's income level and changes due to variations in population. Applied economists have by-passed this problem by postulating a per-capita demand function for an average consumer with an average income, where per-capita quantity demanded is

[3/] Assumption (d) implies that the number of consumers in the group does not change; therefore, to divide aggregate income by the same number throughout the sample period would not change results.

expressed as a function of the retail price of the product in question, the retail prices of substitutes and complements, disposable personal income per-capita, and other factors affecting consumers' demand. Strictly speaking, in an extreme interpretation, this approach of "a typical consumer" assumes that all consumers are alike, namely: that all consumers have the same indifference map and the same income.[4/] The market demand function is obtained by multiplying the "typical demand function" times the average number of consumers in the market during the specific period of time. Thus, under the specified assumptions, an increase in the number of consumers from one period to the next causes not only a shift of the market demand function but may also change its slope depending upon the mathematical form of the function.

A second alternative commonly used in applied work consists of specifying both per-capita income and population as explanatory variables of the market quantity demanded. In this way population is introduced to represent the number of income variables that enter into the market demand function and per-capita income represents the mean value of those variables. The assumption underlying this approach is that the relevant parameters of the income distribution remain constant. In general, the set of implicit or explicit assumptions underlying any formulation of an empirical market demand function will depend on the specific form postulated for both the individual's and the market demand functions. In this study a per-capita demand function for an average consumer with an average income will be considered.

[4/] Wold, Herrman, and Jureen, L., Demand Analysis - A Study in Economics, John Wiley & Sons, Inc., New York, 1953, pp. 117.

The retail demand for beef is expressed in an implicit form and in per-capita terms as follows:

$$\zeta(Q_t^{dpc}, P_t^r; P_t^s, Y_t^{pc}, Z_t, \ldots) = 0 \qquad (2\text{-}1)$$

where Q_t^{dpc} represents the per-capita quantity demanded by consumers during year t,

P_t^r is the retail price of beef,

P_t^s is the retail price of substitutes,

Y_t^{pc} represents per-capita income, and

Z_t represents unspecified or unobserved factors affecting consumer's demand.

Representing the above function a "demand for an average consumer with an average income", on the basis of the specified assumptions traditional microeconomics theory postulates that if the commodity in question can be considered as a "normal good" [$\partial Q/\partial y > 0$, thus $Q(\partial Q/\partial y) > 0$] then the individual demand curve slopes downward ($\partial Q/\partial P < 0$).[5/] In the present study beef is hypothesized to be a "normal good" (non inferior good) thus it is postulated (Q^{dpc}/ P^r) < 0 and (Q^{dpc}/ Y^{pc}) > 0; and based on the definition of substitute goods it generally would be expected[6/]

[5/] This can be shown by use of the theorem of "the negativity of the own substitution effect" that specifies $(\partial Q_r/\partial P_r) + Q_r(\partial Q_r/\partial y) = -\lambda(A_{rr}/A) < 0$; for a more detailed explanation see: Loyd, Cliff, op. cit., pp. 72-73.

[6/] It has been shown that according with the Hicksian definition of substitutes and complements, two goods may be substitutes and still the cross price elasticity of the individual's demand for one of the goods may be negative. The reciprocal is true for complements. See Kuhlman, F. M. and R. G. Thompson, "Substitution and Values of Elasticities"; The American Economic Review, 1966, pp. 506-510. However, generally would be expected $(\partial Q^{dpc}/\partial P^s) > 0$ in the case of substitutes and $(\partial Q^{dpc}/\partial P^c) < 0$ in the case of complements.

$(\partial Q^{dpc}/\partial P^{s}) > 0$, assuming that the composite good theorem also holds for these substitutes (see footnote 1).

Marketing Group's Supply Function

Intermediaries perform many activities between the farm and retail level. In this study it is assumed that all activities (transportation, processing, wholesaling, distributing and retailing) performed by intermediaries may be considered as one operation. The difference between the live animal at the central market and the beef at the retail store is a package of services provided by intermediaries. It is assumed that intermediaries have just one production function and one revenue function for such package of services. Cattle, labor and capital may be considered the three major inputs entering their production function and beef and by-products are the two major outputs supplied by the firm. Perfect competition is assumed in both input and output markets and individual firms are considered to be price takers. Also, all firms are assumed to maximize profits subject to their production function.

From the first order condition for profit maximization it is possible to derive the profit maximizing quantities of outputs and inputs as functions of their prices; in other words, it is possible to derive the supply curves of the outputs (equal to the marginal cost curves) and the demand curves for the inputs where quantities are expressed as functions of prices. The horizontal summation of these supply and demand curves over all firms will yield what may be called the constant price industry supply of output and the constant price industry demand curves of the inputs.

Aggregation viewed in this simple framework assumes that prices of inputs and outputs remain constant for the industry as a whole as for the

individual firms. Thus, if the industry is facing a downward sloping retail demand curve and somewhat sloping supply curves for some of the inputs (i.e., cattle), such an assumption of constant prices (perfect competitive input and output markets) might invalidate the model. It is true that the aggregate functions computed as the horizontal summation of the firm's supply of outputs and demand of input functions would overestimate the industry's reactions to certain price changes. However, at this point theory is being used in search for relevant variables entering these behavioral relationships and for the direction of their influence but not in search of the magnitude of their effects; the latter will be a problem of concern of the estimation part of this study.

Up to this point, the variables included in the above mentioned aggregate functions are the same as those entering the corresponding functions of the firms. Thus, the marketing group's supply is expressed in functional form as follows:

$$\delta(Q_t^s, P_t^r, P_t^f; P_t^{bp}, W_t, i_t, /....) = 0 \qquad (2\text{-}2)$$

where Q_t^s represents quantity supplied by retailers during year t.

P_t^r is the retail price of beef.

P_t^f is the farm price of beef.

P_t^{bp} is the average price of by-products of the cattle-beef industry.

W_t is the average wage rate paid by intermediaries and is a measure of the price of the labor inputs.

i_t is the average interest rate paid by intermediaries and is a measure of the price of the capital input.

As in the case of the individual firm prices of joint outputs (P_t^r and P_t^{bp}) are expected to have a positive effect on quantity supplied (Q_t^s) and prices of complementary inputs (P_t^f, i_t and W_t) are expected to have a negative effect on quantity supplied.[7/] Current instead of lagged prices are used because it is assumed that intermediaries may change their supplies at the retail level within the period by competing at the farm market with export packers for slaughter cattle. The possibility of changes in retail supply within the period is open; the adjustment would come through the price paid for the input (i.e., cattle at the farm level).

A retail market clearing condition ($Q_t^s = Q_t^{dpc} \times \text{Population}_t$) partially closes this system formed by equations (2-1) and (2-2); the price of beef at the farm level (P_t^f) is considered an endogenous variable which relates the farm with the retail market.

International Demand for Argentine Beef

Assuming a free international market it is possible to imagine an international demand for Argentine beef where the quantity demanded (Q_t^{xd}) is a function of the price of the Argentine beef (P_t^{ia}), the prices of other beef that are competing with the Argentine beef in the international market (P_t^{ob}), the aggregate disposable income of those countries who are potential importers of beef (Y_t^{oc}), and prices of inputs used in the packing industry of the importing countries (P_t^{oi}). The assumptions

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[7/] The comparative static properties of the demand for input and supply of output functions in the theory of profit maximization for the firm in a competitive market are presented in many textbooks and there is no need to repeat it here; for a presentation of the general case see Lloyd, op. cit., pp. 173-178.

underlying this demand function are similar to those stated above for the domestic demand for beef. The reasons for the introduction of the mentioned variables are somewhat obvious: prices of other beef competing with Argentinian are considered shifters of the demand for it; incomes are considered shifters of the different consumer demands and also of this derived demand (wholesale level); finally, because this derived demand is the demand for an input, the price of the other inputs enter in its formulation. This relationship represents an international wholesale level demand for Argentine beef and may be written as:

$$\varepsilon\,(Q_t^{xd}, P_t^{ia}; P_t^{ob}, Y_t^{oc}, P_t^{oi}, / \ldots) = 0 \qquad (2\text{-}3)$$

where the variables have the meaning described above.

As in the case of the domestic retail demand, it is postulated $(\partial Q^{xd}/\partial Y^{oc}) > 0$ thus $(\partial Q^{xd}/\partial P^{ia}) < 0$; $(\partial Q^{xd}/\partial P^{ob}) > 0$ and $(\partial Q^{xd}/\partial P_t^{oi}) < 0$ (see footnote 5).

Export Packers' Supply Function

In determining the variables suggested by theory as relevant in the market supply of beef exports function, it is felt that a similar reasoning to the one that was used when considering the marketing group's supply function is applicable. Thus, the quantity of output supplied by export packers (Q_t^{xs}) is a postulated function of the price received for the product (P_t^x), the price paid for the input cattle (P_t^f), the price received for the output by-products (P_t^{bp}), the price paid for the input labor (W_t) and the price paid for the input capital (i_t).

$$\theta\,(Q_t^{xs}, P_t^x, P_t^f; P_t^{bp}, W_t, i_t, / \ldots.) = 0 \qquad (2\text{-}4)$$

As in the case of the marketing group's supply function, prices of joint outputs (P_t^x and P_t^{bp}) are expected to have a positive effect on quantity supplied (Q_t^{xs}) and prices of complementary inputs (P_t^f and W_t) are expected to have a negative effect on quantity supplied (see footnote 7).

The net price received by export packers is the product of the price received at the international market times the rate of exchange dollar /peso minus export retentions and taxes. This is reflected in the following identity of the domestic-international price of Argentine beef exports:

$$P_t^x = (P_t^{ia} \cdot EXR_t) - Tx_t \qquad (2\text{-}5)$$

where EXR_t stands for the average exchange rate in force (standing) during t.

Tx_t is the amount of export taxes and retentions per unit of product in force during t.

and the rest of the variables are as defined previously.

A clearing external market condition ($Q_t^{xd} = Q_t^{xs}$) partially closes the system formed by equations (2-3), (2-4), and (2-5). Again the price of beef at the farm level (P_t^f) is considered an endogenous variable that relates the external and farm level markets.

Export Packers' Demand

The farm level demand for beef exports may be viewed either as the aggregation of the constant price export packers' demand for an input of production (i.e., cattle) or as a derived demand (derived from the international demand for Argentine beef through the use of the external

market clearing condition, see pages 44-45). The variables to be included in the aggregate demand relationship are not exactly the same for both of these approaches. At this point the interest lies in the theory that suggests the variables entering the first one, namely the variables entering the farm level demand for export when viewed as the aggregation of the constant price demands of an input production of export packers.

From the first order condition for profit maximization of export packers (maximization of the profit function subject to the implicit production function) it is possible to derive the profit maximizing quantities of outputs and inputs as functions of their prices. The horizontal summation over all firms (i.e., export packers in this case) of the demand functions for the input in question (i.e., cattle in this case) yields what may be called the constant price industry demand curve for export.

The export packers' demand is postulated as follows:

$$\lambda(Q_t^{dx}, P_t^f, P_t^x, ; \; P_t^{bp}, W_t, i_t, / \ldots) = 0 \qquad (2\text{-}6)$$

where Q_t^{dx} stands for the quantity of cattle demanded by export packers, and the rest of the variables are as defined before.

The comparative static properties of the firm's demand for an input in a competitive market are generalized for the aggregate of those functions (see footnote 7), thus the price of the input cattle (P_t^f), and the prices of other inputs (labor: W_t, and capital: i_t) are expected to have a negative effect on quantity. Prices of joint outputs (beef: P_t^x, and by-products: P_t^{bp}) are postulated as having a positive effect on the quantity of the input (cattle).

Marketing Group's Demand for Domestic Consumption

A reasoning similar to the one applied to the export packers' demand function may be used in determining the variables that enter the marketing group's demand for domestic consumption. Such a function is postulated to be as follows:

$$\mu\,(Q_t^{df}, P_t^f, P_t^r; P_t^{bp}, W_t, i_t, / \ldots) = 0 \qquad (2\text{-}7)$$

where Q_t^{df} represents the quantity demanded by the marketing group for domestic consumption at the farm level during year t.

All other variables have been defined previously.

As when dealing with the export packers' demand function, assume that the comparative static properties of the firm's demand for an input in a competitive market could be generalized for the aggregate function. The price of the cattle (P^f) and the price of other inputs (labor: W_t and capital: i_t) are expected to be negatively related with the quantity demanded and the proces of joint outputs (beef: P_t^r and by-products: P_t^{bp}) are expected to be positively related with the quantity of cattle demanded.

Short Run Farm Level Slaughter Supply

Cattle may be divided into two main categories according to their reproductive quality: (a) steers and yearly steers may be considered either an intermediate or final product and (b) cows, heifers, calves and bulls may be considered intermediate products or <u>capital goods</u>. Price expectations may induce farmers to keep their steers and yearly steers for some time, but in general opportunity cost and diminishing return considerations, and the fact that the highest prices of the market do not

correspond necessarily to the heaviest animals, suggest that these animals are sold within a short period after they enter the category. The same cannot be said of cows, heifers, calves and bulls, because most of them are, actual or potentially, breeding stock and therefore, price expectation may influence farmers' decisions in a different direction and with a different magnitude than in the case of steers and yearly steers.

W. R. Maki comments on this point:

> "...inventory variables perform an indispensable role in connecting the cobweb structure of a model with the accelerator effects arising from inventory adjustment. When cattle price increases, for example, inventories are built-up more rapidly than sales. When prices decline the liquidation of inventories adds to the normal level of sales. For each class of cattle on hand, January 1, a different biological process and management practice and a different response to current market prices would be expected to account for year to year change in the various inventory levels."8/

S. Reutlinger hypothesizes that:

> "...the frequently observed zero or negative supply elasticity for beef is not the result of poor data or faulty statistical analysis. Theoretical specification of supply functions for the separate components of beef slaughter - steers, cows and heifers - leads to an expected positive sign for the supply elasticity of steer slaughter, and an expected negative sign for the supply elasticity of cow slaughter."9/

Considering these arguments the following short run supplies of steers and yearly steers for slaughter (2-8) and of cows, heifers, calves and bulls for slaughter (2-9) are postulated:10/

8/Maki, W. R., "Forecasting Livestock Supplies and Prices with an Econometric Model", Journal of Farm Economics, Vol. 45, No. 3, August 1963, pp. 613-614.

9/Reutlinger, S., "A Short-Run Beef Supply Response", Journal of Farm Economics, Vol. 48, No. 4, Part 1, November 1966, p. 909.

10/The model behind these slaughter functions is similar to that presented by Reca (op. cit., pp. 51-61), where the (continued next page)

$$\xi[S_t^{(1)}, P_t^f; P_{t-1}^f, I_t, X_{t-1}, / \ldots.) = 0 \qquad (2\text{-}8)$$

$$\frac{\partial S_t^{(1)}}{\partial P_t^f} \gtrless 0; \qquad \frac{\partial S_t^{(1)}}{\partial P_{t-1}^f} < 0$$

$$\frac{\partial S_t^{(1)}}{\partial I_t} > 0$$

10/ (continued)

derived inventory at the beginning of the following year (I^*_{t+1}) is assumed to be a function of expected price of beef (P^*_{t+1}) and the other exogenous variables:

$$I^*_{t+1} = \beta_o + \beta_1 P^*_{t+1} + \sum_{i=2}^{n} \beta_i Z_i$$

observed inventory adjustment (production minus slaughter) is assumed a linear function of desired inventory adjustment

$$I_{t+1} - I_t = P_{rd} - S_t$$

$$I_{t+1} - I_t = \gamma[I^*_{t+1} - I_t]$$

and production (P_{rd}) is assumed a linear function of beginning inventory (I_t)

$$P_{rd} = r \cdot I_t$$

The slaughter function is then obtained by successive substitution

$$S_t = (-\gamma\beta_o) - (\gamma\beta_1) P^*_{t+1} + (\gamma + r) I_t - \gamma \sum_{i=2}^{n} \beta_i Z_i$$

or

$$S_t = f(P^*_{t+1}, I_t, Z_2, \ldots, Z_n)$$

Reca also develops a price expectation model of "Nerlovian style" for beef cattle "in general", but the reasoning here is that expectations are of a different nature for final products, intermediate products and capital goods. Assume the following expectations:

- for final products:

$$P^*_{t+1} = P_t$$

(continued next page)

$$\rho[S_t^{(2)}, P_t^f; P_{t-1}^f, I_t, X_{t-1}, CC_t^g, P_{t-1}^g, / \ldots.] = 0 \qquad (2\text{-}9)$$

where

$$\frac{\partial S_t^{(2)}}{\partial P_t^f} < 0; \quad \frac{\partial S_t^{(2)}}{\partial P_{t-1}^f} < 0; \quad \frac{\partial S_t^{(2)}}{\partial I_t} > 0$$

$S_t^{(1)}$ is slaughter of steers and yearly steers during t, measured in number of heads.

$S_t^{(2)}$ is slaughter of cows, heifers, bulls and calves during year t, measured in number of heads.

I_t is total inventory of animals at the beginning of year t.

P_t^f is price of beef at the farm level in year t.

P_{t-1}^f is price of beef at the farm level in year t-1.

X_{t-1} is a measure of pasture conditions.

CC_t^g is a measure of the credit conditions available to the cattle growing sector.

P_{t-1}^g is a measure of opportunity cost (i.e., expected prices of grains represented by an index of grain prices lagged one year).

10/ (continued)

- for intermediate products:

$$P_{t+1}^* = g\ (P_t, P_{t-1})$$

- for capital goods:

$$P_{t+1}^* = h\ (P_t, P_{t-1}, \ldots, P_{t-n}).$$

For simplicity some prices may be safely ignored and thus the expression may also be written as

$$P_{t+1}^* = h'\ (P_t, P_{t-1}).$$

The slaughter function for "final products" is postulated to be positively sloped with respect to price, and the slaughter function for "intermediate products and capital goods" is, on the basis of the above reasoning, postulated to be negatively sloped with respect to price. Thus, the slaughter function for category (a) (2-8) (steers and (continued next page)

The conditions of the pastures determine the carrying capacity, thus they are postulated as having a negative effect on slaughter. Since money is a scarce resource, the availability of credit (loans) to the cattle growing sector influences the inventory demand and is also postulated to be negatively related with slaughter. Expected prices of grains as a measure of the opportunity cost of the beef-cattle versus alternative enterprises is postulated to be positively related with slaughter.

A farm market clearing condition

$$[S_t^{(1)} + S_t^{(2)}] \cdot AW_t = Q_t^{df} + Q_t^{dx}$$

partially closes the system formed by equations (2-7), (2-8), (2-9) and (2-10) where

$$\psi(AW_t, S_t^{(1)}, S_t^{(2)}; X_t, t, /\ldots) = 0 \qquad (2\text{-}10)$$

where AW_t represents the average weight of the animals slaughtered during t,

X_t is a measure of pasture conditions during t, and

t is a trend factor.

The average weight of the animals slaughtered is hypothesized to depend mostly on the composition of slaughter (i.e., the larger the

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10/ (continued)
yearly steers: intermediate and final product) is postulated to have $\frac{\partial S_t^{(1)}}{\partial P_{t-1}} < 0$, and $\frac{\partial S_t^{(1)}}{\partial P_t} \gtreqless 0$ depending upon the relative influence of intermediate and final products. The slaughter function of category (b) (2-9) (cows, heifers, bulls and calves: intermediate products and capital goods) is postulated to have

$$\frac{\partial S^{(2)}}{\partial P_t} < 0 \text{ and } \frac{\partial S^{(2)}}{\partial P_{t-1}} < 0$$

porportion of steers, the larger the average weight), on certain market trends and the conditions of the pastures. In this case the number of steers slaughtered [$S_t^{(1)}$] is postulated to be positively related with total average weight while the number of other animals [$S_t^{(2)}$: cows, heifers, bulls and calves] is postulated to be negatively related with total average weight mainly because of the influence of lighter animals as heifers and calves. The current conditions of the pastures are expected to be positively related with the average weight of marketed animals, because better pastures allow for a better finishing of the animals. The trend factor is introduced to account for the tendency to market lighter animals, thus, this variable is postulated to be negatively related with average weight.

Second Phase: The Structure

The Marketing Group's Behavior and the Model

Given the relatively small size of the cold storage capacity and the relatively fixed transformation coefficient carcass/beef, it is assumed that on an annual basis when all variables are measured in comparable units (dressed weight in this case) the quantity sold to consumers is the same as that bought by the marketing group, ($Q_t^d = Q_t^s = Q_t^{df}$). Thus equations (2-2) and (2-7) can be represented by a single equation given that they contain the same variables. Such an equation which has the characteristics of a structural function may be called the "marketing group's behavior relation"[11/] and can be written as:

[11/] Foote, R. J., "Analytical Tools for Studying Demand and Price Structures", Agricultural Handbook No. 146, United States Department of Agriculture, Agricultural Marketing Service, Washington, D.C., 1958, pp. 101-102.

(continued next page)

$$\sigma(Q_t^d, P_t^r, P_t^f; P_t^{bp}, W_t, i_t, /\ldots) = 0 \qquad (2\text{-}11)$$

This function shows the quantities that the marketing group is willing to handle at various combinations of farm and retail prices. In a similar manner, the "export packers group's behavior relation" shows the quantities that the "export packers group" is willing to handle at various combinations of farm and export prices and may be expressed as:[12/]

$$\tau(Q_t^{dx}, P_t^f, P_t^x, ; P_t^{bp}, W_t, i_t, /\ldots) = 0 \qquad (2\text{-}12)$$

which represents both (2-4) and (2-6) where

11/ (continued)
Hildreth, C., and Jarret, F. G., "A Statistical Study of Livestock Production and Marketing", Cowles Commission for Research in Economics Monograph No. 15, John Wiles & Sons, Inc., New York, 1955, p. 108.

12/ It should be stressed that functions (2-2), (2-7), (2-4) and (2-6) were obtained by aggregating either the firm's supply of output or demand for input functions in competitive markets where the individual firms are considered "price takers". It is postulated that the variables entering these functions are the same as those entering the firm's functions and that the direction of their influence is also the same. However, when defining (2-11) and (2-12) as "behavioral functions" [representing (2-12) - (2-7) and (2-4) - (2-6) respectively] the "price taker" assumption cannot be maintained for the industry as a whole and thus, little can be said about them, except that they describe the behavior of the marketing group (2-11) and the export packers' (2-12). It seems reasonable to expect that the industry is able to transmit changes in retail and export prices back to the farm and vice versa, which would lead us to specify a priori positive signs for the "elasticities of price transmission" [see Chapter II, page 45]. While quantity adjustments are feasible for the individual firm, it may not be so for the industry as a whole and the intended "quantity adjustment" may transform itself in "prices adjustments", thus the effect of prices on quantity in (2-11) and (2-12) may not be an observable phenonema. The above reasoning does not imply that "quantity" disappears as a variable from the "behavioral equations" (2-11) and (2-12) but, rather, constitutes another argument in favor of the simultaneity of the model. In summary, if the behavioral functions (2-11) and (2-12) are normalized in the prices of the outputs (P^r and P^x respectively), no a priori sign is postulated for the coefficient of quantity (Q^d and Q^{dx} respectively), a positive sign is postulated for the coefficients of the price of the input (P^f), negative for the coefficient of the price of other outputs (P^{bp}) and no a priori sign is postulated for the prices of complementary inputs (W and i).

$$Q_t^{dx} = Q_t^{xs}$$

Specific transformations of (2-11) and (2-12) would yield what is usually called "margin equations" ("retail to farm margin equation" and "international to domestic farm margin equation" respectively in this case).

The model formed by equations (2-1), (2-10), (2-3), (2-11), (2-8), (2-9) and (2-10), identity (2-5) and the market clearing condition $[S_t^{(1)} + S_t^{(2)}] \cdot AW_t = [Q_t^d + Q_t^{dx}]$ where $[Q_t^d = Q_t^{dpc} \times Pop.]$, define a system to which partial equilibrium analysis may be applied. This is a structural model because each function parallels economic theory and either describes the behavior of a group of assumed homogeneous economic units (domestic consumers, foreign consumers, domestic intermediaries, export packers and producers) or specifies an institutional constraint (clearing market conditions) or is a definitional equation (identities). Thus, this system reproduced below is developed on the basis of traditional economic theory under a specific set of assumptions and pretends to represent the structure of the Argentine cattle-beef economy.

$\zeta(Q_t^{dpc}, P_t^r ; P_t^s, Y_t^{pc}, Z_t, /\ldots) = 0$ (2-1) Per-capita retail domestic demand.

$\sigma(Q_t^d, P_t^r, P_t^f ; P_t^{bp}, W_t, i_t, /\ldots) = 0$ (2-11) Marketing group's behavior relation.

where $Q_t^d = Q_t^{dpc} \cdot Pop.$

$\varepsilon(Q_t^{xd}, P_t^{la} ; P_t^{ob}, Y_t^{oc}, P_t^{oi}, /\ldots) = 0$ (2-3) International demand for Argentine beef.

$\tau(Q_t^{dx}, P_t^f, P_t^x, ; P_t^{bp}, W_t, i_t, /\ldots) = 0$ (2-12) Export packers group's behavior relation.

where $Q_t^{xd} = Q_t^{dx}$

$P_t^x = (P_t^{ia} \cdot Exr_t) - Tx_t$ (2-5) International domestic price transformation identity.

$\xi[S_t^{(1)}, P^f ; I_t, X_{t-1}, P_{t-1}^f, /\ldots] = 0$ (2-8) Slaughter supply of steers and yearly steers.

$\rho[S_t^{(2)}, P^f ; I_t, P_{t-1}^g, X_{t-1}, CC_t^g, P_{t-1}^f, /\ldots] = 0$ (2-9) Slaughter supply of cows, heifers, bulls and calves.

$\psi[AW_t, S_t^{(1)}, S_t^{(2)} ; X_t, t, /\ldots] = 0$ (2-10) Average weight relation.

where $[S_t^{(1)} + S_t^{(2)}] \cdot AW_t = Q_t^d + Q_t^{dx}$ Farm market clearing condition

All variables have been defined previously. The variables to the left of the semicolon are thought to be mutually determined and are postulated to be endogenous variables. The variables to the right of the semicolon are assumed to be either exogenous to the system or predetermined endogenous.

Actual-Planned Export Relation

The volume of beef exports does not coincide exactly with the dressed equivalent of the animals bought by packers with the purpose of exporting the resulting products. There appears to be two main reasons for such discrepancy, (1) some of the beef products are processed for export (i.e., frozen-deboned beef, canned beef, cooked and frozen, etc...) and losses of weight occur which cannot be taken into account with the types of information available, and (2) the shipping space (hold capacity) available in the short run did not always match the plans of export packers.[13/]

[13/] These discrepancies are considered to be stochastic because no information is available at the moment about the nature of the supply function of shipping space.

The following relationship is postulated to be stochastic in nature and added to the above system to take account of such discrepancy.

$$\omega(Q_t^x, Q_t^{dx} ; Tn_t, /\ldots) \qquad (2\text{-}12')$$

and $Q^x = Q^{xd}$ replaces $Q^{dx} = Q^{xd}$

where Q^x is the volume of beef actually exported, and

Tn_t is a measure of the availability of shipping space.

Third Phase: A Reduced Model

The Derived Demands at the Farm Level

If equations (2-1) and (2-11) are of a specific form, the price at the retail level may be eliminated by using the clearing market constraint $Q_t^{dpc} \cdot Pop_t = Q_t^d$. The relation obtained may be called "derived domestic demand relation"[14/] and is a "partially reduced form"[15/] because it is a particular transformation of the structural equations which contains more than one endogenous variable and not all exogenous or predetermined variables of the system. The relation may be expressed as follows:

$$\phi(Q_t^d, P_t^f ; P_t^s, Y_t^{pc}, Z_t, P_t^{bp}, W_t, i_t, /\ldots) = 0 \qquad (2\text{-}13)$$ Derived domestic demand relation.

Identity (2-5) relates the net price received by export packers (P_t^x) with the price received at the international market (P_t^{ia}). By using

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[14/] Hildreth, C., and Jarret, F. G., op. cit., p. 108.

[15/] Foote, R. J., "Analytical Tools ...," op. cit., pp. 101-102.

Klein's transformation[16/] such a nonlinear identity may be transformed into a linear approximation in the variables. If equations (2-3), (2-12), and (2-12') are of a specific form, it is possible to eliminate the price received at the international market (P_t^{ia}) and the net price received by export packers (P_t^x) from them by means of the transformed identity (2-5) and the clearing market condition $Q_t^x = Q_t^{xd}$. The relationship obtained may be called "derived demand for export" and is a "partially reduced form" because it also is a particular transformation of the structural equations which contains more than one endogenous variable and not all of the exogenous or predetermined variables of the system. This relation may be expressed as follows:

$$\chi(Q_t^{dx}, P_t^f ; Exr_t, Tx_t, P_t^{ob}, Y_t^{oc}, P_t^{oi}, Tn_t, P_t^{bp}, W_t, i_t, /\ldots) = 0$$

(2-14) Derived international demand relation.

Equations (2-8), (2-9), (2-10), (2-13), (2-14) and the farm market clearing condition, $[S_t^{(1)} + S_t^{(2)}] \cdot AW_t = Q^d + Q^{dx}$, define a system that may be subjected to partial equilibrium analysis. From an empirical point of view an advantage of this system is that the coefficients of the relationships may be estimated even if observations on the price at the retail level (P_t^r) or the net price received by export packers (P_t^x) and the price received at the international market (P_t^{ia}) are not available.

The Elasticities in Both Forms of the Model

Working with a model similar to the one presented above, Hildreth and Jarrett have shown that if the presumptions in (2-11)$_\sigma$ $(\frac{\partial P^r}{\partial Q^d})_\sigma \geq 0$

[16/] These transformations are of the type: $X \cdot Y = \bar{X} \cdot Y + \bar{Y} \cdot X - \bar{X} \cdot \bar{Y}$ and $X/Y = \bar{X}/\bar{Y} + (1/\bar{Y})X - (\bar{X}/\bar{Y}^2)Y$. See: Klein, Lawrence, R., A Textbook of Econometrics, Row, Peterson and Company, Evanston, Illinois, Second Printing, 1956, pp. 120-121.

and the elasticity of price transmission of the marketing group: $\epsilon_{pt\sigma} = \frac{P^f}{P^r} (\frac{\partial P^r}{\partial P^f})_\sigma \leq 1$ hold, "...consumer demand is at least as elastic with respect to both price and income as is derived demand."[17/] This statement follows from relations (2-15) and (2-16) below which are directly applicable to relations $(2\text{-}1)_\zeta$, $(2\text{-}11)_\sigma$ and $(2\text{-}13)_\phi$ under discussion

$$E_{p^f\phi} = \frac{E_{p^r\zeta} \quad E_{pt\sigma}}{1 - (\frac{\partial P^r}{\partial Q^d})_\sigma \; (\frac{\partial Q^d}{\partial P^r})_\zeta} \tag{2-15}$$

$$E_{y\phi} = \frac{E_{y\zeta}}{1 - (\frac{\partial P^r}{\partial Q^d})_\sigma \; (\frac{\partial Q^d}{\partial P^r})_\zeta} \tag{2-16}$$

A similar statement can be made for the relationship between the international demand for Argentine beef" $(2\text{-}3)_\varepsilon$ and the "derived demand for exports" $(2\text{-}14)_\chi$; i.e., if in $(2\text{-}12)_\tau$ $(\frac{\partial P^x}{\partial Q^{dx}})_\tau \geq 0$, and the elasticity of price transmission of export packers:

$$E_{pt\tau} = \frac{P^f}{P^x} \cdot (\frac{\partial P^x}{\partial P^f})_\tau \leq 1$$

hold, then,

$$E_{p^f\chi} \geq E_{p^x\varepsilon} \text{ , and}$$

$$E_{y^{oc}\chi} \leq E_{y^{oc}\varepsilon}$$

which follows from relations (2-17) and (2-18) below

[17/] Hildreth, Clifford and F. G. Jarret, op. cit., pp. 108-112.

$$E_p f_\chi = \frac{E_p x_\varepsilon \cdot E_{pt\tau}}{1 - (\frac{\partial Q^x}{\partial P^x})_\varepsilon \cdot (\frac{\partial P^x}{\partial Q^x})_\tau} \tag{2-17}$$

$$E_y oc_\chi = \frac{E_y oc_\varepsilon}{1 - (\frac{\partial Q^x}{\partial P^x})_\varepsilon \cdot (\frac{\partial P^x}{\partial Q^x})_\tau} \tag{2-18}$$

The price elasticity of total demand at the farm level may be computed as a weighted sum of the elasticity of derived demand for domestic consumption and the elasticity of derived demand for exports.

$$E_p f_Q t = (\alpha_d \cdot E_p f_\phi) + (\alpha_{dx} \cdot E_p f)_\chi$$

where

$$\alpha_d = \frac{Q^d}{Q^d + Q^{dx}} \quad \text{and} \quad \alpha_{dx} = \frac{Q^{dx}}{Q^d + Q^{dx}}$$

CHAPTER III
STATISTICAL MODEL

Statistical Model

The statistical model paralleling the previously named "structural model" is presented in this chapter. Special attention is then focused on the assumptions, the identification of the equations, and the estimation procedure to be used.

Traditional microeconomic theory says very little about the mathematical form of the postulated functional relationships. Thus, keeping in mind that simplicity is not an undesirable attribute, each equation is specified to be linear in the variables. On the basis of the discussion presented in the previous chapters the variables are classified as "endogenous variables" (Y_t's) if they are to be explained by the system, as "predetermined exogenous" (X_t's) if they can be safely considered as determined by outside phenomena, as "predetermined endogenous" (Y_{t-1}'s) if their values have been determined within the system in a previous period, and as "stochastic" (U_t's) if the variables can assume any value within a segment of the real space and there exists a corresponding probability of occurrence for each value. Consistent with the economic model and previous reasoning the statistical model that parallels the "structural model" in Chapter II is specified below. Each equation is normalized in terms of the variable whose values are to be explained by the equation and the coefficients β_{ij} of the normalized variable equals one in that

case. $\beta_{i,j}$'s are used to represent the parameter of the endogenous variables Y's; and $\gamma_{i,k}$'s represent parameters of the predetermined variables X's and Y_{t-1}'s, where the subscript "i" represents the equation and "j" and "k" represent the variable. The intercepts are denoted by $\gamma_{i,o}$ where the second subscript is zero.

$$Y_{1t} + \beta_{1,2} Y_{2t} + \gamma_{1,1} X_{1t} + \gamma_{1,2} X_{2t} + \gamma_{1,0} = U_{1t}$$

(per-capita retail domestic demand) (3-1)

$$Y_{2t} + \beta_{2,3} Y_{3t} + \beta_{2,4} Y_{4t} + \gamma_{2,4} X^{t}_{45} + \gamma_{2,5} X_{5t} + \gamma_{2,6} X_{6t} + \gamma_{2,0} = U_{2t}.$$

(marketing group's behavior relation) (3-2)

$$Y_{5t} + \beta_{3,6} Y_{6t} + \gamma_{3,7} X_{7t} + \gamma_{3,8} X_{8t} + \gamma_{3,0} = U_{3;t}$$

(international demand for Argentine beef) (3-3)

$$Y_{5t} + \beta_{4,7} Y_{7t} + \gamma_{4,9} X_{9t} + \gamma_{4,0} = U_{4t}$$

(actual-planned export relation) (3-4)

$$Y_{8t} + \beta_{5,4} Y_{4t} + \beta_{5,7} Y_{7t} + \gamma_{5,4} X_{4t} + \gamma_{5,5} X_{5t} + \gamma_{5,6} X_{6t} + \gamma_{5,0} = U_{5t}$$

(export packers group's behavior relation) (3-5)

$$Y_{9t} + \beta_{6,4} Y_{4t} + \gamma_{6,10} X_{10t} + \gamma_{6,11} X_{11t-1} + \gamma_{6,16} X_{16t-1} + \gamma_{6,0} = U_{6t}$$

(slaughter supply of steers and yearly steers) (3-6)

$$Y_{10t} + \beta_{7,4} Y_{4t} + \gamma_{7,10} X_{10t} + \gamma_{7,11} X_{11t-1}$$
$$+ \gamma_{7,16} X_{16t-1} + \gamma_{7,12} X_{12t} + \gamma_{7,13} X_{13t} + \gamma_{7,0} = U_{7t}$$

(slaughter supply of cows, heifers, bulls and calves) (3-7)

$$Y_{11t} + \beta_{8,9} Y_{9t} + \beta_{8,10} Y_{10t} + \gamma_{8,2} X_{2t} + \gamma_{8,14} X_{14t} + \gamma_{8,0} = U_{8t}$$

(average weight equation) (3-8)

$$Y_{1t} \cdot X_{3t} - Y_{3t} = 0$$

(per-capita to total transformation identity) (3-9)

$$Y_{8t} - Y_{6t} \cdot X_{15t} = 0$$

(international-domestic price transformation identity) (3-10)

$$[Y_{9t} + Y_{10t}] \cdot Y_{11t} - Y_{3t} - Y_{7t} = 0$$

(farm market clearing conditions). (3-11)

The above system of equations defines a "complete model" since there are eleven structurally complete equations and eleven are the endogenous variables whose values are to be explained by the system. The variables are defined below. The symbols to the left of the semicolon are the variables defined in Chapter II, and the symbols to the right of the semicoln denote the empirical measurement used to represent the variables on the left.[1/]

Endogenous Variables

Q_t^{dpc} : Y_{1t} = per-capita quantity demanded measured in kg/year per capita, multiplied by 10^2.

P_t^r : Y_{2t} = average retail price of beef in pesos of 1960 per 100 kgs.

Q_t^d : Y_{3t} = total domestic quantity demanded in thousand tons of dressed beef.

P_t^f : Y_{4t} = price at the farm level in pesos of 1960, per 100 kgs. dressed weight equivalent.

Q^{xd} : Y_{5t} = quantity exported of refrigerated beef in 100 tons.

P_t^{ia} : Y_{6t} = price of Argentine refrigerated beef in the international market in U.S. dollars of 1960 per 10,000 kgs. FOB Buenos Aires (value of refrigerated beef exports divided by volume).

[1/] The derivation of each series and an evaluation of its adequacy and limitation imposed on the model are discussed in Appendix A.

Q_t^{dx} : Y_{7t} = quantity demanded for export at the farm level in 100 tons dressed weight.

P_t^x : Y_{8t} = net price received for exports of refrigerated beef in pesos of 1960 per 100 kgs.

$S_t^{(1)}$: Y_{9t} = number of animals slaughtered, classified under the category of steers (novillos) and yearly steers (novillitos) in 1,000 heads.

$S_t^{(2)}$: Y_{10t} = number of animals slaughtered, classified under the categories of "cows, heifers, bulls and calves" in 1,000 heads.

AW_t : Y_{11t} = average dressed weight per slaughtered head in 100 grams.

Predetermined Variables

Y_t^{pc} : X_{1t} = per-capita net national income in pesos of 1960.

Z_t : t : X_{2t} = "time" (as measured by numbering years consecutively) with $X_{2,1935} = 1 \times 10^2$ and $X_{2,1966} = 32 \times 10^2$) as proxy for trend factor.

Pop_t : X_{3t} = population at June 30th, in thousand inhabitants.

P_t^{bp} : X_{4t} = wholesale price index of hides in pesos of 1960 per 100 kgs. as proxy for price-index of by-products.

W_t : X_{5t} = general wage index for the Federal Capital in cents of 1960 per hour as proxy for the index of wages paid by packers.

X_{6t} = dummy variable with zeroes for the periods 1935-45 and 1956-66, and ones for the period 1946-55 (years of interventionism in the beef-cattle industry).

P_t^{ob} : X_{7t} = wholesale price of British beef in U.S. dollars of 1960 per 100 kgs.

Y_t^{oc} : X_{8t} = index of real incomes of importing countries, 1955 = 10000.

Tn_t : X_{9t} = tons of vessels loaded in Buenos Aires's docks, in 1,000 metric tons per year, as proxy for shipment capacity.

I_t : X_{10t} = inventory of animals at the beginning of the year in 1,000 heads.

X_{t-1} : X_{11t-1} = dummy variable used to represent drought years (ones whenever in either the cattle breeding or fattening subregion the rainfall index falls below 85, where normal year = 100; zeroes elsewhere) lagged one year.

CC^b : X_{12t} = net balance at the end of the year of "credits granted to cattle farmers," in 10 million pesos of 1960.

P^g_{t-1} : X_{13t} = index of prices of grains (in pesos of 1960) lagged one year.

X_t : X_{14t} = dummy variable used to represent drought years, as above but without lag.

Exr_t : X_{15t} = average exchange rate dollar/peso during t, in constant money of 1960.

P^f_{t-1} : Y_{4t-1} : X_{16t-1} = dressed equivalent of the farm price lagged one year.

Stochastic Variables

U_i (i = 1,...,8) = the random component.

It is assumed that U_{it}'s: 1) belong to the real space: 2) are random variables; 3) have an expected value of zero for every t; 4) are homoscedastic over time; 5) are not autocorrelated over time; 6) are independent from any predetermined (endogenous and exogenous) variable; and 7) the joint distribution of U's is normal. A set of five additional assumptions regarding the econometric model become necessary in order to insure the attainment of maximum likelihood estimators of the parameters of equations (3-1) through (3-8).[2/] These assumptions, which follow the ones listed above are: 8) the parameters β_{ij} and γ_{ik} (i = 1,...,8 ; j = 1,...,10 ; k = 0,1,...,16) are constant and unknown; 9) the matrix formed by the coefficients of the endogenous variables is non-singular,

[2/] Equations (3-9), (3-10), and (3-11) are identities with known parameters (not necessarily constant) thus, the above specified assumptions are not necessary for them.

i.e. the system can be solved uniquely for the endogenous variables in terms of the predetermined (endogenous and exogenous) variables: 10) the vectors of predetermined variables are a linearly independent set; 11) equations (3-1) through (3-8) are identifiable (discussed later); and 12) that the moment matrix of predetermined (endogenous and exogenous) variables about zero is well behaved in the limit.[3/]

This set of assumptions, together with the a priori sign specified for the coefficients, complete the maintained hypothesis. The signs of the coefficients are specified in accordance with the economic model presented in Chapter II as follows:[4/]

$\beta_{1,2} > 0;\ \gamma_{1,1} < 0;\ \gamma_{1,2} \gtrless 0$

$\beta_{2,3} \gtrless 0;\ \beta_{2,4} < 0;\ \gamma_{2,4} > 0;\ \gamma_{2,5} \gtrless 0;\ \gamma_{2,6} > 0$

$\beta_{3,6} > 0;\ \gamma_{3,7} < 0;\ \gamma_{3,8} < 0;$

$\beta_{4,7} < 0;\ \gamma_{4,9} < 0;$

$\beta_{5,4} < 0;\ \beta_{5,7} \gtrless 0;\ \gamma_{5,4} > 0;\ \gamma_{5,5} \gtrless 0;\ \gamma_{5,6} > 0;$

$\beta_{6,4} \lessgtr 0;\ \gamma_{6,10} < 0;\ \gamma_{6,11} < 0;\ \gamma_{6,16} > 0;$

$\beta_{7,4} > 0;\ \gamma_{7,10} < 0;\ \gamma_{7,11} < 0;\ \gamma_{7,16} > 0;\ \gamma_{7,12} > 0;\ \gamma_{7,13} < 0;$

$\beta_{8,9} < 0;\ \beta_{8,10} > 0;\ \gamma_{8,2} > 0;\ \gamma_{8,14} > 0;$

[3/] These assumptions are required for consistent estimators as explained by Christ, op. cit., pp. 354-355.

[4/] Note that the direction of the inequalities should be reversed if the explanatory variables are transposed to the other side of the equality sign.

No a priori sign is hypothesized for the intercepts (γ_{io}); $i = 1,\ldots,8$).[5/]

The parameters of the model are to be estimated on the basis of secondary data generated by the economy for the period 1935-1966. The assumption of perfect competition in the retail and farm level markets cannot be fully supported for the 32 years that form the sample. The years 1946 through 1955 were characterized by increasing governmental interventionism in the export oriented agricultural markets in general, and cattle beef sector in particular.[6/] Because much of the weight of the interventionism laid on the shoulders of the marketing group and

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[5/] Note that some variables present in the economic model have been excluded from the statistical model, thus, their respective coefficients are implicitly postulated equal to zero. The reason for excluding them is that either (a) no information is available [as in the case of "export taxes" (Tx_t) and "interest rates" (i_t)], or (b) to include them would lead to burdensome computation not justified by their theoretically explanatory power [as in the case of "prices of other inputs in importing countries (P_t^{oi})] or (c) to maintain the simplicity of the model in terms of the number of variables included [as in the case of "prices of substitutes" (P_t^s)].

Note also that "exchange rate" is assumed to be an exogenous variable. Though it is recognized that this may not be the case given that beef exports represented an important percentage of total export earnings for the period 1935-1966, there are two reasons, besides that of practical necessity, that help support this assumption, namely (1) the exchange rate depends on the supply and demand of foreign exchange (when its level is determined in the market) that may or may not be partially influenced by beef exports (i.e., capital flow, expectation, hedging against inflation, etc... are also relevant determinants of supply and demand of foreign exchange), and (2) as indicated in Chapter I, throughout the period under analysis different policies were applied to the exchange market and thus, the economic nature of this variable has been altered toward an instrument variable of policy makers.

[6/] It is not within the scope of this study to go into detailed listing of the different policies applied and their possible effects on the market structure. For a fairly complete description see Peffer, E. Louise, "The Argentine Cattle Industry under Peron", Food Research Institute Studies, Vol. I, No. 2, May 1960.

export packers, a dummy variable X_{6t} (zeroes for 1935-1945 and 1957-1966, and ones for 1946-1955) is included as a shifter in the marketing group's behavior equation (3-2) and the export packers' behavior equation (3-5).

Identification

Identification has been defined as the problem of "...deducing the values of the parameters of the structural relations from a knowledge of the reduced-form parameters."[7/] An equation is said to be exactly identified, over-identified or under-identified if a unique set, more than one set, or no set of estimates of the structural parameters can be derived from the estimates of the reduced form parameters.

The above system of equations can be rearranged and written in matrix[8/] notation to consider the identifications of the equations as follows:

$$\underset{(11,11)}{B} \cdot \underset{(11,1)}{Y_t} + \underset{(11,17)}{\Gamma} \cdot \underset{(17,1)}{X_t} = \underset{(11,1)}{U_t}$$

[7/] Johnston, J., "Econometric Methods", McGraw-Hill Book Co., Inc., N.Y., 1963, pg. 243.

[8/] A previous transformation of the identities in the system is required [see footnote 16, Chapter II], where (3-9), (3-10) and (3-11) can be rewritten as (3-9'), (3-10') and (3-11') respectively

$$- \bar{X}_3 Y_{1t} + Y_{3t} - \bar{Y}_1 X_{3t} + (\bar{Y}_1 \cdot \bar{X}_3) = v_9 \qquad (3\text{-}9')$$

$$Y_{8t} - \bar{X}_{15} Y_{6t} - \bar{Y}_6 X_{15t} + (\bar{Y}_6 \cdot \bar{X}_{15}) = v_{10} \qquad (3\text{-}10')$$

$$Y_{3t} + Y_{7t} - \bar{Y}_{11} Y_{9t} - \bar{Y}_{11} Y_{10t} - (\bar{Y}_9 + \bar{Y}_{10}) \cdot Y_{11t} + (\bar{Y}_9 + \bar{Y}_{10}) \cdot \bar{Y}_{11} = v_{11} \qquad (3\text{-}11')$$

where the v's are transformation errors.

where B is the matrix of the coefficients of the endogenous variables, Y_t represents the vector of endogenous variables, Γ stands for the matrix of coefficients of predetermined variables, X_t is the vector of predetermined variables and U_t represents the vector of random components.

The necessary condition (also called order condition) for identifiability of the structural equations (3-1) through (3-8) is that the number of variables excluded from the equation in question must be at least equal to the number of endogenous variables minus one.[9/] According to this condition, all the stochastic equations in the system (3-1) through (3-8) are over-identified. The necessary and sufficient condition (also called rank condition) for identifiability is that the rank of $[B_{\Delta\Delta}, \Gamma_{**}]_i$ be equal to the number of endogenous variables in the system (G) minus one.[10/]

$$\rho[B_{\Delta\Delta}, \Gamma_{**}]_i = G - 1 ; i = 1,\ldots,8$$

where $[B_{\Delta\Delta}, \Gamma_{**}]_i$ is defined as the submatrix of $[B, \Gamma]$ that contains all the coefficients corresponding to the variables not present in the ith equation.

By manipulating the rows and columns of $[B_{\Delta\Delta}, \Gamma_{**}]_i$ (for $i = 1,\ldots,8$) it can be shown that there is no a priori evidence that the necessary and sufficient conditions are not fulfilled. Because the actual values of the parameters are unknown, the question of whether such condition is in fact satisfied cannot be answered. The estimates obtained for the parameters will provide a basis for a more complete analysis of the identification power of the model.

[9/] Johnston, J., op. cit., pp. 250-251.

[10/] _____, op. cit., pp. 251-252.

Estimational Procedure

All the stochastic equations in the model under discussion are over-identified. Thus, the following statistical procedures may be used in the estimation: (a) weighted or unweighted instrumental variables; (b) the limited-information single equation (LISE) or the least variance ratio (LVR) technique; or (c) the two stage least squares procedure (2SLS). The case of instrumental variables was rejected because of the arbitrariness in the selection of "the instrumental variable" which may lead to discrepancies among the estimates obtained by using different instruments. The basic objection to the use of the LISE or LVR techniques is the burdensomeness of the computational work and the fact that the advantages of LISE (or LVR) over 2SLS when dealing with small samples are not well established.[11/] The 2SLS procedure was selected for use in this study because (a) the selection of "instruments" is less arbitrary,[12/] (b) computational simplicity, (c) estimates are consistent and asymptotically normal (asymptotically efficient under the normality assumption),[13/] and (d) results of Monte Carlo studies appear to show that 2SLS structural estimators are the least bothered by specification error and multicollinearity.[14/]

[11/] Johnston, op. cit., pp. 263, 293-294. Christ, Carl F., "Econometric Models and Methods", John Wiley and Sons, Inc., N.Y. 1967, pp. 470-481.

[12/] 2SLS estimator is a special case of instrumental variables, where the "instruments" are the "calculated" values of Y's and the observed values of X's. Christ, Carl. F., op. cit., pg. 437 and 446.

[13/] Christ "conjectures" about the asymptotically normal property of 2SLS estimator in a model that includes lagged endogenous variables as explanatory variables (what he called Model 3). Christ, op. cit., pg. 441.

[14/] Christ, op. cit., pg. 478. Johnston, op. cit., pg. 294.

Test of Hypothesis

Whether or not the explanatory variables have a significant effect on the explained variable is usually tested by comparing the computed t-value with the t-statistic at certain probability level under the assumption of "normally distributed error terms". While 2SLS yields asymptotic variance estimators of the parameters, the small sample properties of such estimators are unknown and the value of the t-test is subject to question.[15/] In this study standard errors are computed for the estimated coefficients and then compared to the coefficient. Any coefficient larger than its standard error is considered to have an important influence on the dependent variable. Coefficients are also evaluated with respect to sign and magnitude in terms of maintained hypothesis.[16/]

[15/] Christ comments: "Analogous statistics (referring to the computed t) from the two stage least squares and full information methods also have approximately the normal distribution. These statistics have the normal distribution approximately (not exactly) for several reasons: $\hat{\beta}_i$ and $\hat{\gamma}_k$ are only approximately normal, not exactly, and their expectation in general do not exist and so they cannot be unbiased; the $\hat{\sigma}$'s are estimators of the approximate (not the exact) standard deviations of the $\hat{\beta}$'s and $\hat{\gamma}$'s, ... The appropriate number of degrees of freedom for the approximately distribution of (3-27) (referring to the computed t) is not clear. Most practitioners use the sample size diminished by the number of unknown parameters in the equation..." Christ, op. cit., page 515.

[16/] The coefficient of multiple correlation (R^2) is presented for each estimated equation, even though it is of limited value in analyzing the goodness of the fit, to facilitate comparison with other studies. Christ stresses such limitation to an extreme when saying that "...this statistic is of no value as an indicator of the usefulness of an estimated structural equation." [Christ, op. cit., pg. 519].

Multicollinearity

High correlation among the assumed independent variables makes it difficult to disentangle their separate influence in the explained variable.[17/] The problem is to detect how high can the zero-order correlatio coefficient between two predetermined variables be, before seriously affecting the estimates of their respective standard errors. Unfortunately since the true standard errors of the estimates are unknown, very little can be done along this line. Nevertheless, at least the presence of serious multicollinearity can be detected. Three criteria are used in this study for that purpose: (1) the elements of the zero-order correlation matrix (R) are examined for coefficients close to unity; (2) the elements of the inverse of the correlation matrix (R^{-1}) are examined for extremely large values compared to the values of the elements in (R) and (3) the matrix ($R^{-1}R$) is computed and verification is made that checks out in the form of an identity matrix, $[(R^{-1}R) = I]$.[18/]

Analysis of the Residuals

A common statistical problem that may invalidate the statistical tests is the violation of the assumption of serially independent

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[17/] The exogenous variables may in fact be independent but still show a high degree of correlation due to strong trends over time. The effects of multicollinearity have been discussed by many writers. Christ, op. cit pg. 387-390, 478-479; Johnston, op. cit., pg. 201-207.

[18/] If the det. of R = $|R| = 0$, the inverse (R^{-1}) is undefined and $[R^{-1}R] = I$ cannot be obtained. Determinant $|R| = 0$ is equivalent to det $|X'X| = 0$.

disturbance terms.[19] In the case of over-identified equations containing no lagged endogenous variables Durbin (1957)[20] recommends the "Durbin-Watson test for serial correlation" as "a good approximate test." When some of the predetermined variables are lagged values of the endogenous variables the test is, at best, only approximate and should be interpreted with caution. In this study the Durbin-Watson test is retained as an "approximate test", for expository convenience and to facilitate comparison with other studies. The test statistically is:

$$d = \frac{\sum_{2}^{T} (\hat{u}_t - \hat{u}_{t-1})^2}{\sum_{1}^{T} (\hat{u}_t)^2}$$

The hypothesis of no serial correlation is not rejected if the value of d falls between the upper bound d_u and $(4 - d_u)$. For values of $d < d_1$ (lower bound) the presence of positive serial correlation is indicated, and $d > 4 - d_1$ is interpreted as negative serial correlation being present. The regions bounded by d_1 and d_u, and $(4 - d_u)$ and $(4 - d_1)$ give inconclusive test.

Data

The data used in the estimation of the parameters of equations (3-1) through (3-8) are time series for the period 1935-1966 that were chosen

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[19] The omission of variables that move with a similar pattern and are serially correlated, or errors of measurement in the "explained" variable may be, among others, the causes of serial correlation of the disturbance term. Johnston, op. cit., pp. 177-199. See also: Hildreth, C. and J. Lu, "Demand Relations with Auto Correlated Disturbances", Technical Bulletin 276, Ag. Exp. Station, Michigan State University, Nov. 1960.

[20] Quoted by Christ, op. cit., pp. 528-529.

so as to approximate as closely as possible the economic variables specified in Chapter II. Lack of availability of reliable secondary data represented one of the main obstacles which had to be circumbened. The source of each series and the computational procedure used to obtain each empirical variable used in the estimation is described in Appendix A.

CHAPTER IV
STATISTICAL ESTIMATES AND EMPIRICAL RESULTS

In this chapter the estimates obtained for the parameters of the structural model are presented for each equation separately. The sign of each estimate is contrasted to the hypothesized sign and its magnitude interpreted in terms of elasticities, which are compared with other estimates when available. The degree of identification of the structure is discussed in terms of the identification of each particular equation, the consistency of the sign of the estimates with those specified in the maintained hypothesis, and the magnitude of the estimates relative to their standard errors. Finally, a comparison is made between 2SLS and OLS estimates, and also between the estimated structure and those estimates of the structure obtained on the basis of a sub-sample period (1935-46 and 1958-66).

The figures in parenthesis below the estimated coefficients are their respective standard errors. A double asterisk indicates that the respective coefficient is more than twice as large as its standard error, and a single asterisk indicates that is larger than its standard error. The Durbin-Watson statistic is represented by the letter "d". A plus sign (+) attached to the computed d-value indicates the presence of positive serial correlation; the letter (i) indicates inconclusive test and the letter (a) indicates that the hypothesis of non-serially correlated disturbances is not rejected at the .05 level of significance.

The Estimated Equations

(4-1) Per-capita Domestic Retail Demand

$$Y_1 = 9938.36 - 1.464\ Y_2 + .036\ X_1 + .376\ X_2 + \hat{U}_1$$

$$(.184)^{**} \quad (.031)^{*} \quad (.280)^{*} \qquad R^2 = .81$$

$$d = 1.197^{(+)}$$

As may be noticed, the estimates of the price and income slopes have the sign previously hypothesized. The magnitude of these estimates should be interpreted as the effect of the respective variable on the explained variable Y_1, all other variables in the equation remaining constant.[1/]

The coefficient of Y_2 indicates that a change of 1 peso (of 1960) in the retail price of beef would result in a change of 1.464 kgs. in the per-capita quantity demanded of beef in the opposite direction.

As the coefficient of X_1 indicates, an increase (decrease) of 1,000 pesos (of 1960) in the per-capita net national income would result in an increase (decrease) of .36 kg. in the per-capita quantity demanded.

Every year an increase of .376 kg. is observed in the per-capita quantity demanded for beef due to unspecified factors as indicated by the coefficient of X_2. Because of high multicollinearity the coefficient of this variable may be picking up some of the income effect, due to changes in X_1.[2/]

[1/] The magnitude of all estimates presented in this chapter should be interpreted as ceteris paribus statements, i.e., as the effect of the respective variable on the explained variable, when all other variables present in the given equation remain at their previous values.

[2/] The zero order correlation coefficient between X_1 and X_2 is $r_{X_1X_2} = .91$ which means that it becomes difficult to disentangle their separate influences.

The presence of positive serial correlation in the residuals is indicated by the "d-statistic". The causes of this may be, among others, errors of measurement in the "explained variable", or the omission of explanatory variables that are serially correlated, or incorrect specification of the form of the equation.

The unexpalined residuals obtained in the statistical fit of the above demand equation are plotted in Figure 2 and compared with a volume index of per-capita consumption of substitutes (pork, lamb and fish). Comparing the behavior of both series, it appears that at least part of the unexplained changes in consumption of beef could be explained by opposite changes in the consumption of substitutes. According to traditional demand theory prices of substitutes (and not quantity) enter the demand function as explanatory variables; but, whenever the information available on prices of substitutes (pork and lamb) was introduced as predetermined variables in the present study, either the estimates of the coefficients came out with the "unexpected sign" or they were smaller than their standard errors. Furthermore, the serial correlation problem was still present in such cases. This suggests that either lagged consumption may be an explanatory variable of the actual level of consumption,[3/] or that prices of substitutes used in the analysis were not very good proxies of the actual prices, or that prices of substitutes are simultaneously determined with the price of beef and thus the assumption of independence of these prices with the error term was being violated. This last possibility merits further consideration.

[3/] Such was the case postulated by Guadagni, and Guadagni and Petrecolla, op. cit.

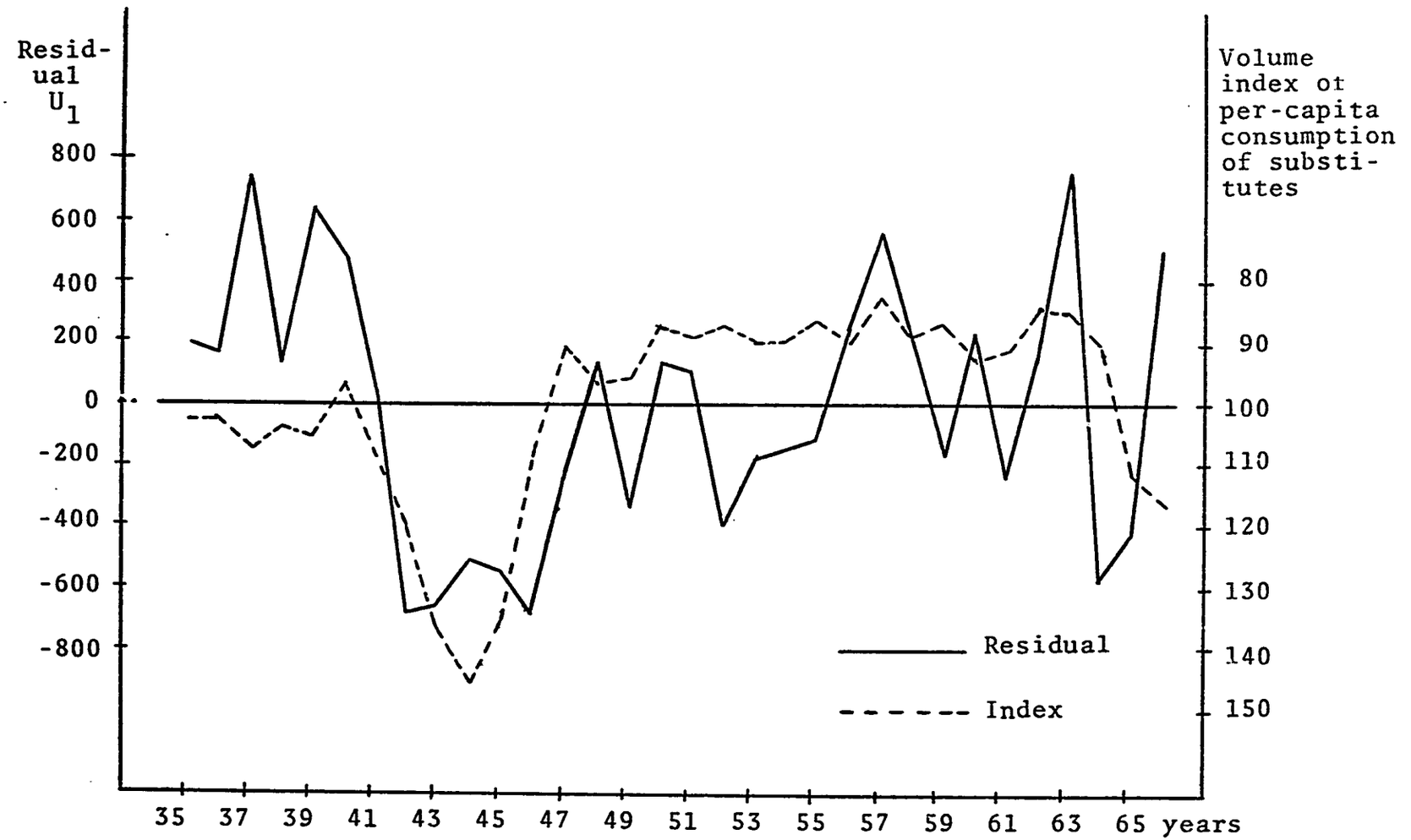

Figure 2. Unexplained Residual and Volume Index of Per-Capita Consumption of Substitutes.

The retail price and income elasticities computed at mean values on the basis of the above estimates are as follow:

$$\hat{E}_{Y_{2\zeta}} = \left(\frac{\partial Y_1}{\partial Y_2}\right)_\zeta \frac{\bar{Y}_2}{\bar{Y}_1} = (-1.464)\ \frac{2535.48}{8110.80} = -.46 \quad \text{(retail price elasticity)}$$

$$\hat{E}_{X_{1\zeta}} = \left(\frac{\partial Y_1}{\partial X_1}\right)_\zeta \frac{\bar{X}_1}{\bar{Y}_1} = (.036)\ \frac{35,724.81}{8,110.80} = .16 \quad \text{(retail income elasticity)}$$

The aggregate retail demand function being defined as the per-capita retail demand function times population (X_3), where population is considered as a shifter of both the intercept and the slope coefficients, imply that the price and income elasticities for the aggregate function assume the same value as those obtained for the per-capita function, i.e.,

$$\hat{E}_{Y_2}\ (\zeta \cdot X_3) = \left(X_3 \cdot \frac{\partial Y_1}{\partial Y_2}\right) \frac{\bar{Y}_2}{(\bar{Y}_1 \cdot X_3)} = \hat{E}_{Y_2\zeta} = -.46$$

$$\hat{E}_{X_1}\ (\zeta \cdot X_3) = \left(X_3 \cdot \frac{\partial Y_1}{\partial X_1}\right) \frac{\bar{X}_1}{(\bar{Y}_1 \cdot X_3)} = \hat{E}_{X_1\zeta} = .16$$

Comparison of these estimates with the ones obtained in previous studies (shown in Table 1) provides a point of reference for their evaluation.

In terms of magnitude the estimate obtained in this study for the price elasticity at the retail level is considerably larger than the one found by Otrera, though it does not appear to differ substantially from the ones obtained by Guadagni and Petrecolla. Thus, it corroborates the idea that a policy of increases in the retail price of beef with the purpose of discouraging domestic consumption is of relative scope.

Table 1. Estimates of Retail Price and Income Elasticities Obtained from Different Studies

Study	Guadagni (1914-59)[1]		Guadagni and Petrecolla (1935-61)[2]		Otrera (1945-64)[3]	This study (1935-66)
retail level elasticity	Short run	Long run	Short run	Long run	Short run at mean values	Short run at mean values
Price	-.29	-.51	-.476	-.533	-.20	-.46
Income	.28	.49	.383	.429	.41	.16

1/ Guadagni, A., op. cit., pg. 531.

2/ Guadagni, A. and A. Petrecolla, op. cit., pg. 281.

3/ The elasticities have been converted from 1964 values to mean values, i.e.,

$$e_d = (-.0598)\ \frac{53.305}{15.9215} = -.20$$

$$e_b = (.0903)\ \frac{71.505}{15.9215} = .41$$

Otrera, W. R., op. cit., pp. 105-107.

The estimate obtained for the income elasticity appears to be substantially lower than those obtained in previous studies. In the case of the ones obtained by Guadagni and Petrecolla, the difference may be partially due to the form of the demand function (constant elasticity type) postulated by the authors, and to the statistical procedure used in the estimation (OLS). In the case of the estimate obtained by Otrera, the discrepancy may be due to the different sample period used in the estimation and to the specific nature of the "retail demand function" postulated. In Otrera's model "total supply of beef", together with price, income, population and time, is specified as an explanatory variable of

domestic quantity demanded.[4/] If the time factor (X_2; proxy for unspecified factors affecting consumer's demand) is excluded in the estimation, an income elasticity of .43 is obtained, which does not appear to differ substantially from those obtained in other studies. Thus, the idea that the time factor was picking up some of the income effect appears to be corroborated.

In summary, the coefficient of price appears reasonably well identified (considering that it is about eight times larger than its standard error), while the coefficient of the income variable seems to be underestimated, mainly because of the above mentioned problem of multicollinearity.

Even if an income elasticity of .43 is considered as being closer to the true structural parameter, in terms of magnitude both price and income elasticities appear to be low if compared with the ones found in other countries. However, it should be stressed that when the consumption of the particular commodity is already at "a high level", as is the case of beef in Argentina, estimates like these are not unreasonable.

(4-2)σ Marketing Group's Behavior Equation

$$Y_2 = 1981.40 - \underset{(.194)^*}{.243\, Y_3} + \underset{(.115)^{**}}{.962\, Y_4} - \underset{(.074)^*}{.084\, X_4} - \underset{(.123)^*}{.212\, X_5} - \underset{(.114)^{**}}{.349\, X_6} + \hat{U}_2$$

$$R_2 = .86$$

$$d = 1.224^{(i)}$$

The estimates of the coefficients of Y_4, X_4 and X_6 have the <u>a priori</u> specified sign; while no sign was specified for the rest of the coefficients.

[4/] Otrera, op. cit., pp. 76, 90-93.

The sign of the coefficient of Y_3 indicates that a change in the quantity marketed for domestic consumption (Y_3) is associated with a change in the opposite direction of the retail price of beef (Y_2). A feasible explanation could be offered: the marketing group may attempt to maintain total gross returns in the face of changes in the marketed volume.

The coefficient of the price at the farm level Y_4 (dressed equivalent) indicates that a unit change in that variable results in an approximately similar change of the price at the retail level (Y_2). This is consistent with the idea that the marketing group may have been attempting to maintain total gross returns. The elasticity of price transmission (at mean values) is defined as[5/]

$$E_{pt\sigma} = \left(\frac{\bar{Y}_4}{\bar{Y}_2}\right) \left(\frac{\partial Y_2}{\partial Y_4}\right)_\sigma = \left(\frac{1968.35}{2535.48}\right) (.962) = .7468$$

and a 10% increase in the price at the farm level - other things equal - leads to a 7.5% increase of the price at the retail level.

The magnitude of the coefficient of X_4 suggests that an increase (decrease) of 1 peso (in 1960 purchasing power) in the price per kg. of hides (proxy for by-products) would result in a decrease (increase) of 084 pesos in the retail price of beef Y_2. Stated in other terms, a change in the price of the joint output would lead to a change in the same direction of the price paid for the input (Y_4), which is consistent with the notion that the marketing group attempted to maintain total gross returns.

[5/] Hildreth, C. and F. Jarrett, op. cit., pp. 110-111.

The coefficient of X_6 (dummy variable) indicates that as a result of interventionism in the beef-cattle industry during the period 1946-55, the retail price of beef decreased, on the average, 3.49 pesos of 1960 per kg. This is not too surprising since reduction of retail price was one of the explicit objectives of the interventionist policy.

(4-3)ε International Demand for Argentine Beef

$$Y_5 = -1369.01 - .895\,Y_6 + .713\,X_7 + .265\,X_8 + \hat{U}_3$$

$$(.253)^{**} \quad (.167)^{**} \quad (.063)^{**} \qquad R^2 = .58$$

$$d = 1.29^{(i)}$$

All the estimates have the a priori specified sign (i.e., demand is negatively sloped, and price of competing products and the purchasing power of foreign consumers are positive shifters of demand for Argentine beef), and are at least three times as large as their standard errors.

The estimate of the coefficient of Y_6 indicates that an increase (decrease) of 10 dollars (1960) in the price per ton of Argentine refrigerated beef will lead to a decrease (increase) of about 9,000 tons in the quantity demanded. The price elasticity evaluated at mean values is

$$E_{Y_6\varepsilon} = \left(\frac{\bar{Y}_6}{\bar{Y}_5}\right) \left(\frac{\partial Y_5}{\partial Y_6}\right) = \left(\frac{4333.6}{3103.1}\right) (-.895) = -1.25$$

hence, a 10% change in the price of Argentine refrigerated beef would lead to a 12.5% change in the quantity demanded in the opposite direction. This elasticity estimate appears to be low compared with other estimates shown in Table 2.

Table 2. Estimates of the Price Elasticity of Foreign Demand for Argentine Beef

	Product	Data Used	Nature of the Model	Form of the Model	Estimate or Computed Elasticity
I.	Chilled beef U.K.[1/]	annual data 1956-61	single equation	linear in the variables	-1.9
II.	Chilled beef U.K.[2/]	quarterly data 1963-65	single equation	linear in the variables	-2.4
III.	Chilled beef U.K.[2/]	quarterly data 1963-65	single equation	constant elasticity	-1.9
IV.	Refrigerated beef, all destiny[3/]	annual data 1935-66	simultaneous equations	linear in the variables	-1.25

[1/] Herrmann, L. F. and R. E. Branson, op. cit., pp. 8-9.

[2/] Nores, G., "British demand for Argentine beef", unpublished paper presented in Ag. Econ. 605, Purdue University 1967.

[3/] Computed on the basis of the above estimates.

However, it should be stressed that estimates I, II and III have been computed under the explicit assumption that quantity exported is determined independently of current export price. Such an assumption has not been made in the estimation of IV.

As indicated by the coefficient of X_7 an increase of 10 dollars (of 1960) in the price per ton of competing beef (X_7) would have led to an increase of 7.130 tons in the quantity demanded of Argentine refrigerated beef. The cross price elasticity evaluated at mean values is

$$E_{X_7\varepsilon} = \left(\frac{\bar{X}_7}{\bar{Y}_5}\right) \left(\frac{\partial Y_5}{\partial X_7}\right)_\varepsilon = \left(\frac{8346.7}{3103.1}\right) (.713) = 1.92$$

which implies that a 10% change in the price of substitutes of Argentine beef would lead to a 19.2% change, in the same direction, in quantity demanded of Argentine refrigerated beef.

The coefficient of X_8 in (4-3) indicates that consumption of Argentine refrigerated beef is strongly influenced by the purchasing power of foreign consumers. The price elasticity evaluated at mean values is

$$E_{X_8\varepsilon} = \left(\frac{\bar{X}_8}{\bar{Y}_5}\right) \left(\frac{\partial Y_5}{\partial X_8}\right)_\varepsilon = \left(\frac{10,050.9}{3,103.1}\right) (.265) = .86$$

consequently, a 10% increase in national income of importing countries would have led to an increase of 8.6% in the quantity demanded of Argentine refrigerated beef.

(4-4)ω Actual-planned Export Relation (Refrigerated Beef)

$$Y_5 = -1248.96 + .657\ Y_7 + .099\ X_9 + \hat{U}_4$$

$$(.082)^{**} \quad (.027)^{**} \qquad R^2 = .79$$

$$d = 1.624^{(a)}$$

All estimates have the a priori specified sign and are at least three times as large as their respective standard errors.

The coefficient of Y_7 indicates that an increase (decrease) of 1,000 tons of beef (dressed equivalent) bought by packers for export would lead to an increase (decrease) of 657 tons in actual exports of refrigerated beef (Y_5). The coefficient of X_9 indicates that a change of 1,000 tons in shipment capacity would have been associated with changes in similar directions of 9.9 tons in actual exports of refrigerated beef.

(4-5)τ Export packers' Behavior Equation

$$Y_8 = -367.57 + 1.166\ Y_4 - .026\ Y_7 - .079\ X_4 + .138\ X_5 - .785\ X_6 + \hat{U}_5$$

$$(.151)^{**} \quad (.097) \quad (.091) \quad (.164) \quad (.270)^{**}$$

$$R^2 = .84$$

$$d = 1.630^{(i)}$$

The estimates of the coefficients of Y_4, X_4 and X_6 have a priori specified signs. No sign was specified a priori for the coefficients of Y_7 and X_5.

The coefficient of Y_4 indicates that an increase (decrease) of 1 peso in the price of the farm level (dressed equivalent) would result in an increase (decrease) of 1.16 pesos in the export price Y_8. The elasticity of price transmission evaluated at mean value is

$$E_{pt\tau} = \left(\frac{\bar{Y}_4}{\bar{Y}_8}\right) \left(\frac{\partial Y_8}{\partial Y_4}\right)_\tau = \left(\frac{1968.35}{2202.38}\right) (1.166) = 1.04$$

which says that, a 10% change in the price at the farm level - other things equal - would have led to a similar change in the export price (Y_8).

As indicated by the coefficient of Y_7, a change in the quantity marketed for export is associated with an opposite change in the export price (Y_8). This suggests that export packers may have also attempted to maintain total gross returns in the face of changes in the marketed volume.

An increase (decrease) of 1 peso (in 1960 purchasing power) per kg. of joint product would result in a decrease (increase) of .079 pesos in the export price of beef Y_8 as indicated by the coefficient of X_4. Stated in other terms, an increase in the price of the joint output would lead to an increase in the price paid for the input (Y_4),[6/] which is also consistent with the above mentioned notion that export packers may have been attempting to maintain total gross returns.

The coefficient of X_6 (dummy variable) indicates that interventionism in the beef-cattle industry during the period 1946-55 resulted in a decrease of the export price received by packers (Y_8).

(4-6)ξ Slaughter Supply of Steers and Yearly Steers

$$Y_9 = -316.55 + .258\,Y_4 + .120\,X_{10} + .293\,X_{11} - .446\,X_{16} + \hat{U}_6$$

$$(.162)^* \quad (.010)^{**} \quad (.122)^{**} \quad (.152)^{**} \qquad R^2 = .89$$

$$d = 1.892^{(a)}$$

[6/] This can be easily seen if equation (4-5) is normalized in Y_4.

All estimates have the a priori specified sign.

The coefficient of Y_4 indicates that a change in 1 peso of 1960 in the price at the farm level (dressed equivalent) would result in a change, in the same direction, of 25,800 heads in the slaughter supply of steers and yearly steers. The price elasticity evaluated at mean values is

$$E_{Y_4\xi} = \left(\frac{\bar{Y}_4}{\bar{Y}_9}\right) \left(\frac{\partial Y_9}{\partial Y_4}\right)_\xi = \left(\frac{1968.35}{4810.76}\right) (.258) = .105$$

consequently, an increase of 10% in current farm price would result in an increase of 1.05% in the slaughter of steers and yearly steers. The magnitude of this elasticity coefficient seems reasonable given that not much can be done to increase production within the year, and its sign is consistent with the notion of a positively sloping supply of final products.

An increase (decrease) of one million heads in beginning inventory would lead to an increase (decrease) of 120,000 heads in the slaughter of steers and yearly steers as indicated by the coefficient of X_{10}. The elasticity evaluated at mean values is:

$$E_{X_{10}\xi} = \left(\frac{\bar{X}_{10}}{\bar{Y}_9}\right) \left(\frac{\partial Y_9}{\partial X_{10}}\right)_\xi = \left(\frac{45290.0}{4810.75}\right) (.120) = 1.13$$

A change of 10% in the beginning inventory would result in a change, in the same direction, of 11.3% in the number of steers and yearly steers supplied for slaughter.

As is indicated by the coefficient of X_{11} (dummy variable), unfavorable conditions of pastures (whenever the rainfall index of either one of the two subregions fell below the critical level of 85) lead to an

average increase in current slaughter of 293,000 steers and yearly steers.

A change of 1 peso of 1960 in the price paid the previous year at the farm level (dressed equivalent) would result in a change, in opposite direction, of 44,600 heads in the current slaughter of steers and yearly steers (mostly yearly steers according to the theoretical formulation in Chapter II) as indicated by the coefficient of X_{16}. In terms of an elasticity evaluated at mean values

$$E_{Y_{4t-1}\xi} = \left(\frac{\bar{Y}_{4t-1}}{\bar{Y}_9}\right) \left(\frac{\partial Y_9}{\partial Y_{4t-1}}\right)_\xi = \left(\frac{1935.73}{4810.76}\right) (-.446) = -.179$$

and an increase (decrease) of 10% in the price paid at the farm level in the previous year would result in a 1.79% decrease (increase) in current slaughter of steers and yearly steers.

(4-7)ρ Slaughter Supply of Cows, Heifers, Bulls and Calves

$$Y_{10} = -441.21 - \underset{(.417)}{.244\, Y_4} + \underset{(.031)^{**}}{.178\, X_{10}} + \underset{(.336)^{*}}{.569\, X_{11}} - \underset{(.368)^{**}}{1.019\, X_{16}}$$

$$- \underset{(.565)^{**}}{1.156\, X_{12}} + \underset{(.784)}{.172\, X_{13}} + \hat{U}_7$$

$$R^2 = .75$$

$$d = 1.157^{(i)}$$

All coefficients have the <u>a priori</u> specified sign. An increase (decrease) of 1 peso in the current farm price of beef (dressed equivalent) would result in a decrease (increase) of 24,400 heads in the aggregate of cows, heifers, bulls and calves sent to slaughter as is indicated by the coefficient of Y_4. The elasticity computed at mean values is

$$E_{Y_4\rho} = \left(\frac{\bar{Y}_4}{\bar{Y}_{10}}\right) \left(\frac{\partial Y_{10}}{\partial Y_4}\right)_\rho = \left(\frac{1968.35}{4284.59}\right) - .244 = -.112$$

hence, a 10% increase in the current price at the farm level would result in a decrease of 1.12% in the aggregate number of cows, heifers, bulls and calves sent to slaughter.

The coefficient of X_{10} indicates that an increase of one million heads in beginning inventory would result in an increase of 179,000 heads in the current total slaughter of cows, heifers, bulls and calves. In terms of elasticity evaluated at mean values

$$E_{X_{10}\rho} = \left(\frac{\bar{X}_{10}}{\bar{Y}_{10}}\right) \left(\frac{\partial Y_{10}}{\partial X_{10}}\right)_\rho = \left(\frac{45290.0}{4284.59}\right) (.178) = 1.88$$

at 10% increase in beginning inventory would result in 18.8% increase in current slaughter of cows, heifers, bulls and calves.

The coefficient of X_{11} (dummy variable) indicates that conditions of pastures (whenever the rainfall index of either one of the two sub-regions fell below the critical level of 85) lead to an average increase in current slaughter of 569,000 cows, heifers, bulls and calves.

An increase of 1 peso of 1960 in the price paid the previous year at the farm level would result in a decrease of 101,900 heads in current slaughter of cows, heifers, bulls and calves; as indicated by the coefficient of X_{16}. The elasticity computed at mean values is:

$$E_{X_{16}\rho} = \left(\frac{\bar{X}_{16}}{\bar{Y}_{10}}\right) \left(\frac{\partial Y_{10}}{\partial X_{16}}\right)_\rho = \left(\frac{1935.73}{4284.59}\right) (-1.019) = -.46$$

which may be interpreted as a 10% increase in the previous price at the farm level (dressed equivalent) resulting in a 4.6% decrease in current

slaughter of the animals included in this category.

As indicated by the coefficient of X_{12}, an increase of 100 million pesos (of 1960) in credits granted to the cattle sector would result in a decrease of 11,560 heads slaughtered (cows, heifers, bulls and calves). Because monetary situations have varied from relatively high liquidity to excessive tightness during the considered period, the estimate obtained for the coefficient of X_{12} represents only the average influence of credit on slaughter corresponding to those different circumstances. Under tight monetary situations such an influence may be larger than under situations of relative high liquidity.

A 10% increase in the price of grains, X_{13}, would lead to an increase of 3.7% in current slaughter of cows, heifers, bulls and calves, as suggested by the elasticity computed at mean values

$$E_{X_{13}\rho} = \left(\frac{\bar{X}_{13}}{\bar{Y}_{10}}\right) \left(\frac{\partial Y_{10}}{\partial X_{13}}\right)_{\rho} = \left(\frac{9199.4}{4284.59}\right) (.172) = .37$$

(4-8)ψ Average Weight Equation

$$Y_{11} = 2233.18 + .057\ Y_9 - .071\ Y_{10} - .030\ X_{14} - .028\ X_3 + \hat{U}_8$$

$$(.028)^{**} \quad (.012)^{**} \quad (.014)^{**} \quad (.016)^{*} \qquad R^2 = .73$$

$$d = 2.016^{(a)}$$

All estimated coefficients have the signs specified a priori. Their magnitudes are interpreted as follows (ceteris paribus):

An increase of 100,000 heads in the slaughter of steers and yearly steers would result in an increase of .57 kg. in the average weight per ghtered head. The elasticity computed at mean values is

$$E_{Y_9\psi} = \left(\frac{\bar{Y}_9}{\bar{Y}_{11}}\right) \left(\frac{\partial Y_{11}}{\partial Y_9}\right)_\psi = \left(\frac{4810.76}{2147.74}\right) (.057) = .128$$

which may be interpreted as a 10% increase (decrease) in the slaughter of steers and yearly steers resulting in a 1.28% increase (decrease) in the average weight per slaughtered head.

An increase of 100,000 heads in the aggregate slaughter of cows, heifers, bulls and calves would result in a decrease of .71 kg. in the average weight per slaughtered head; which in terms of elasticity measured at mean values could be stated as

$$E_{Y_{10}\psi} = \left(\frac{\bar{Y}_{10}}{\bar{Y}_{11}}\right) \left(\frac{\partial Y_{11}}{\partial Y_{10}}\right)_\psi = \left(\frac{4284.59}{2147.74}\right) (-.071) = -.141$$

A 10% increase in the aggregate slaughter of cows, heifers, bulls and calves would result in a 1.41% decrease in the average weight per slaughtered head.

The average dressed weight of the animals sent to slaughter tend to be lower during drought years as indicated by the estimate of the coefficient of X_{14} in (4-8). Because Argentine cattle production is characterized by "natural and artificial grazing", unfavorable conditions of the pastures due to serious droughts would lead to the marketing of unfinished products, hence, to the reduction of the average weight per slaughtered head.

Other things equal, the average dressed weight of the animals sent to slaughter diminishes .28 kg. per year. This result does not come as a surprise given that the tendency to market lighter animals has been directly observable in the market.

The Identification Power of the Model

The *a priori* information provided in the maintained hypothesis was enough to allow for the fulfillment (not to insure it) of both order and rank conditions for the model to be structure identifying. If the estimates of the parameters that are smaller than their respective standard errors are deleted, and the remaining estimates are substituted in the statistical model for their respective parameters, it can be shown that both order and rank conditions for identification are satisfied ex-post, in the case of the particular sample period chosen. Thus, it can be said that the power of the model of being structure-identifying is corroborated by the data. However, because the identification power of a model can vary, some equations - or parameters within an equation - are said to be *well*, *acceptably*, or *poorly* identified depending upon whether (a) the particular equation is exactly or over-identified; (b) the sign of the estimates are consistent with the maintained hypothesis; and (c) the magnitudes of the estimates relative to their standard errors indicate that the variables in question have an effect on the explained variable.

In the particular case under study, (a) all stochastic equations of the system were over-identified, (b) all estimates had the sign specified in the maintained hypothesis, and (c) all estimates but five ($\beta_{5,7}$, $\gamma_{5,4}$, $\gamma_{5,5}$, $\beta_{7,4}$, and $\gamma_{7,13}$) are larger (2/3 of them being at least twice as large) than their respective standard errors. Thus, one might judge the equations and parameters of the system to be between *well* and *acceptably* identified for the specific purpose of this study.

No claim is made here that the above statistical fit *is* the true structure of the annual Argentine cattle-beef economy. The methodology

of statistical inference precludes making this type of claim. Also, the estimators of the statistical procedure used in the estimation are in fact biased, but they are consistent and thus, unbiased only in the probability limit as the sample size increases. Furthermore, the specific form of the model postulated is "at best" only an approximation of the true underlying structure. As Koopmans puts it:

> "The research worker that constructs a model does not really believe that reality is exactly described by a "true" structure contained in the model. Linearity, discrete time lags, are obviously only approximations. At best, the model builder hopes to construct a model that contains a structure which approximates reality to a degree sufficient for the practical purposes of the investigation."[7/]

Since the main objective of this study is to explain price variations at the farm level, it is felt that the structure of the annual Argentine cattle-beef economy has been sufficiently well identified for such purpose and thus, the above statistical fit [equations (4-1) to (4-8)] is considered to be a reasonably good approximation of the true structure.

Ordinary Least Squares Estimates

The estimates obtained by applying ordinary least squares (OLS) are presented in Appendix B. By comparing them with the ones obtained by applying 2SLS it may be observed that in general OLS estimates were smaller in absolute magnitude than the corresponding 2SLS estimates.[8/]

[7/] Koopmans, T., "Identification Problems in Economic Model Construction", in Hood, W. C. and T. Koopmans, Studies in Econometric Methods, Cowles Commission Monography 14, John Wiley & Sons, N.Y. 1953, pg. 46.

[8/] Some coefficients changed substantially in terms of magnitude as in the case of coefficient of price (Y_4) in the slaughter supply of cows, heifers, bulls and calves, which OLS estimate is three times as large as its corresponding 2SLS estimate.

Also, OLS estimates, in general, have smaller standard errors than 2SLS estimates. This was to be expected according with the results obtained in Monte Carlo experiments.[9/]

More evidence of the presence of positive serial correlation in the residuals is observable in the equations estimated by applying OLS. In every case the computed d-statistic is smaller than the one obtained when applying 2SLS. Though the Durbin-Watson test is considered only "an approximate test" in the case of over-identified equations, the difference between the computed d-values in 2SLS fit and OLS fit is, in some cases, of a too large mangitude to be neglected. Hence, it is felt that OLS procedure may in fact be introducing simultaneity biases in the estimates of the coefficients.[10/]

Estimates of the Structure Based on 21 Observations

As pointed out in Chapter III, the assumption of perfect competition in the retail and farm level markets could not be fully supported for the 32 years that form the sample. The years 1946 through 1955 were characterized by an increasing governmental interventionism in the export oriented agricultural markets in general, and cattle-beef sector in particular. Because much of the weight of the interventionism laid on the shoulders of the marketing group and export packers, a dummy variable

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[9/] Results of Monte Carlo studies have shown that OLS usually results in smaller standard error for the coefficient than 2SLS; though biases of the coefficients were in many cases considerably larger for OLS estimates than for 2SLS estimates. [see Christ, op. cit., pp. 477-481].

[10/] However, this is not conclusive evidence given that when some of the equations include lagged endogenous variables, 2SLS estimating procedure would generally be expected to yield residuals that are less autocorrelated than those of OLS.

X_6 was introduced as a shifter in the marketing group's behavior equation (3-2) and the export group's behavior equation (3-5).

As a mean of checking the validity of the results presented in this chapter, the model was subject to estimation excluding the years 1947 to 1957. A slight modification was made to account for the possibility of a change in the structure from pre to post-intervention period. A dummy variable X_{17} (zeroes for 1935-46 and ones for 1958-66) replaced the dummy X_6 in the marketing group's and export packers' behavior equations, and was introduced as a shifter of the actual-planned export relation (3-4). The time variable X_2 would account for the possible change in structure of per-capita retail demand (3-1) and the average weight equation (3-8).

The estimates obtained on the basis of this sub-sample period are presented in Appendix C. It may be seen that all estimates of parameters have the same sign as those obtained on the basis of the complete sample (1935-1966). Also, with the exception of $\hat{\beta}_{23}$ and $\hat{\beta}_{24}$, most estimates are of a similar magnitude. Furthermore, the size of the coefficients relative to their standard errors are in most cases, similar.

Because 2SLS estimators have the property of being consistent for "large samples", the estimates obtained for the parameters on the basis of 32 observations (1935-1966) are judged to be less biased than those obtained on the basis of 21 observations (1935-46 and 1958-66).

An Alternative Set of Estimates

If total beef exports Y'_{5t} and the corresponding prices Y'_{6t} and Y'_{8t} are replaced for refrigerated beef exports Y_{5t} and the corresponding prices Y_{6t} and Y_{8t}, an alternative set of estimates for equations (4-3),

(4-4) and (4-5) is obtained. Such estimates are presented in Appendix D, together with the corresponding OLS estimates, and 2SLS estimates obtained on the basis of the sub-sample period. Variables not defined previously are:

Y'_{5t} = total quantity exported of beef in 100 tons.

Y'_{6t} = average price of Argentine exports of beef in U.S. dollars of 1960 per 10,000 kgs. FOB Buenos Aires, computed as value of beef exports divided by volume.

Y'_{8t} = net price received for total exports of beef in pesos of 1969 per 100 kgs.

X_{17} = a dummy variable (zeroes for 1935-46 and ones for 1958-66).

It is observed that, in general, the coefficients do not differ substantially from those of equations (4-3), (4-4) and (4-5). The ones that appear to differ most are the coefficients of X_7 and X_8 in the "foreign demand for Argentine beef" (D-1)(a), but such differences were to be expected given that the empirical measurements used to represent these variables were more appropriate for the case of "refrigerated beef" than for "total beef" which includes frozen-deboned beef, canned beef, cooked and frozen, and other items. Also, the larger coefficient of Y_7 in the actual-planned export relation (D-2)(a) was to be expected given that in fact total volume of exports is larger than exports of refrigerated beef.

In summary, the alternative set of estimates obtained on the basis of "total beef exports" is consistent with the estimates of the structure which were obtained on the basis of "refrigerated beef exports". The reason for placing more confidence in the latter over the former,

is that the composition of the items included under "total beef exports" has varied substantially throughout the sample period compared to the composition of "refrigerated beef exports"; hence, the average prices computed as value/volume,[11/] would lead to more biased estimates of the parameters in the case of "total beef exports".

[11/] This is the case of a simple weighted average

$$W_{Q_o}(P_o) = \frac{\Sigma Q_{io} P_{io}}{\Sigma Q_{io}} = \Sigma \frac{Q_{io}}{\Sigma Q_{io}} \cdot P_{io} = \Sigma q_{io} P_{io}$$

where the value of the index $W_{Q_o}(P_o)$ will change when either some price (P_{io}) changes or some weight (q_{io}) changes, or both. Because the interest here lies on the measurement of changes in prices (P_i's) only, changes in the composition of exports (q_i's) would introduce a bias in the index as computed by $W_{Q_o}(P_o)$. More appropriate indexes would be the Laspeyres type $[I_L = \frac{\Sigma P_n Q_x}{\Sigma P_o Q_x}]$ or the Paasche's index $[I_p = \frac{\Sigma P_n Q_n}{\Sigma P_o Q_n}]$, or better the so called "ideal index" $II = \sqrt{\frac{\Sigma P_n Q_o}{\Sigma P_o Q_o} \cdot \frac{\Sigma P_n Q_n}{\Sigma P_o Q_n}}$ but the information available at the moment precluded their computation.

CHAPTER V
THE ELASTICITIES AT THE FARM LEVEL AND THE ECONOMIC HYPOTHESES

In this chapter the elasticities of derived demands for both domestic consumption and exports are computed on the basis of the estimates presented in the previous chapter. The elasticity of the aggregate demand at the farm level which is defined as the weighted sum of domestic consumption and export elasticities is compared with the price elasticity of total slaughter in terms of stability of equilibrium. Finally, the economic hypotheses developed in Chapter I are analyzed on the basis of the empirical estimates.

Price Elasticity of Derived Demand for Domestic Consumption

The aggregate retail demand function which is defined as the per-capita retail demand function times population, where population is considered a shifter of both the intercept and the slope coefficients, implies that the price elasticity of the aggregate function assumes the same value as that obtained for the per-capita demand, as was explained in the previous chapter.[1/]

[1/] The aggregate function is obtained by solving (4-1) [or (3-1)] and (3-9) for Y_3. If the linear transformation (3-9') is used instead of (3-9) the resulting aggregate function will explicitly include population (X_3) as a variable and shifts in the intercept and slope coefficients will depend on the mean values $\bar{Y}_1$ and $\bar{X}_3$.

The aggregate retail demand function obtained at mean values ($X_3 = \bar{X}_3$) is

$$Y_3 = 1737.89 - .256\ Y_2 + .006\ X_1 + .0657\ X_2 + W_1 \qquad (5\text{-}1)_\zeta,$$

where $W_1 = \hat{U}_1 \cdot \bar{X}_3$ and the price elasticity is

$$E_{Y_2\zeta} = \left(\frac{\bar{Y}_2}{\bar{Y}_3}\right) \left(\frac{\partial Y_3}{\partial Y_2}\right)_\zeta = \left(\frac{2535.48}{1422.99}\right) (-.256) = -.46$$

The price and income elasticities of derived demand for domestic consumption are computed at mean values, by using formulas (2-15) and (2-16)[2/] respectively, as follows:

$$\hat{E}_{Y_4\phi} = \frac{\hat{E}_{Y_2\zeta} \cdot \hat{E}_{pt\sigma}}{1 - \left(\frac{\partial Y_2}{\partial Y_3}\right)_\sigma \left(\frac{\partial Y_3}{\partial Y_2}\right)_\zeta} = \frac{(-.46)\ (.7468)}{1 - (-.243)\ (-.256)} = -.36\cancel{6}^{3}$$

$$\hat{E}_{X_1\phi} = \frac{E_{X_1\zeta}}{1 - \left(\frac{\partial Y_2}{\partial Y_3}\right)_\sigma \left(\frac{\partial Y_3}{\partial Y_2}\right)_\zeta} = \frac{(.006)\ \left(\frac{35,724.81}{1,422.99}\right)}{1 - (-.243)\ (-.256)} = .160$$

The relative changes implied by the computed price elasticity are that a 10% increase (decrease) in farm price would result in a 3.66% decrease (increase) in the quantity demanded for domestic consumption; while the computed income elasticity implies that a 10% increase in net national income per-capita would result in a 1.6% increase in the quantity

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[2/] The aggregate retail demand function (5-1) is represented by ζ, the derived demand at the farm level by ϕ and the marketing group's behavior equation by σ.

demanded at the farm level for domestic consumption.[3/]

Price Elasticity of Derived Demand for Exports

Solving functions (4-3) [international demand for Argentine beef], (4-4) [actual-planned export relation] and (3-10) [foreign-domestic price transformation identity] for Y_7 in terms of Y_8 and X_{15},[4/] the following relation is obtained,

$$Y_7 = -6496.79 - 2.5414\ Y_8 + 1.1032\ X_{15} + 1.085\ X_7 + .4033\ X_8 - .151\ X_9 + W_2 \qquad (5\text{-}2)_\varepsilon$$

where the quantity demanded for exports (Y_7) is expressed as a function of the price received for exports for refrigerated beef expressed in domestic currency, (Y_8), the current exchange rate, (X_{15}), the price of substitutes of Argentine beef, (X_7), the income level of importing countries, (X_8), and the availability of shipping space, (X_9), and W_2 is a linear function of $\hat{U}_3$, $\hat{U}_4$ and v_{10}.

The price elasticity of derived demand for exports is computed at mean values by using formula (2-17)[5/]

[3/] The same comments made in the analysis of the magnitude of the income elasticity of demand at the retail level are relevant here.

[4/] In order to make explicit the effect of exchange rate on quantity demanded for export, identity (3-10) is expressed as a linear approximation

$$Y_{6t} = \frac{Y_{8t}}{X_{15t}} = \left[\frac{\bar{Y}_8}{\bar{X}_{15}}\right] + \left[\frac{1}{\bar{X}_{15}}\right] Y_{8t} - \left[\frac{\bar{Y}_8}{(\bar{X}_{15})^2}\right] X_{15t} + v_{10} = (4333.57) + (1.8658)\ Y_{8t} - (.809867)\ X_{15t} + v_{10}$$

[5/] Where equation (5-2) is represented by ε, the export packers' behavior equation (4-5) by τ, and the derived demand for exports by χ. Formula (2-18) is applicable to any other exogenous variable in (5-2).

$$\hat{E}_{Y_4X} = \frac{E_{Y_8\varepsilon} \cdot E_{pt\tau}}{1 - (\frac{\partial Y_7}{\partial Y_8})_\varepsilon (\frac{\partial Y_8}{\partial Y_7})_\tau} = \frac{(-1.0726)\ (1.04)}{1 - (-2.5414)\ (-.026)} = -\ 1.195$$

$$\text{for } \hat{E}_{Y_8\varepsilon} = (\frac{\bar{Y}_8}{\bar{Y}_7})\ (\frac{\partial Y_7}{\partial Y_8})_\varepsilon = (\frac{2202.38}{5218.06})\ (-2.5414) = -\ 1.0726$$

This estimate appears to indicate that in fact "derived demand for export" is elastic with respect to price: a 10% change in farm price would result in a 12% change, in opposite direction, in the quantity demanded for exports; what is consistent with the a priori reasoning provided in Chapter I.

The exchange rate elasticity of derived demand for exports is evaluated at mean values by using formula (2-18).

$$\hat{E}_{X_{15}X} = \frac{\hat{E}_{X_{15}\varepsilon}}{1 - (\frac{\partial Y_7}{\partial Y_8})_\varepsilon (\frac{\partial Y_8}{\partial Y_7})_\tau} = \frac{(1.133)}{1 - (-2.5414)\ (-.026)} = 1.213$$

$$\text{for } \hat{E}_{X_{15}\varepsilon} = (\frac{\bar{X}_{15}}{\bar{Y}_7})\ (\frac{\partial Y_7}{\partial X_{15}})_\varepsilon = (\frac{5359.62}{5218.06})\ (1.1032) = 1.133$$

Hence, a 10% devaluation in the domestic currency would result in an increase of approximately 12% in the quantity demanded for exports.[6/] This result is not surprising considering that the elasticity of price transmission in the export packers' behavior equation (4-5) is close to unity ($E_{pt\sigma} = 1.04$). The above estimate indicates that the exchange

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[6/] For a definition of "exchange rate in constant money" see Appendix A.

rate is in fact a powerful shifter of derived demand for exports and hence, an important shifter of aggregate demand at the farm level.

Price Elasticity of Aggregate Demand at the Farm Level

Aggregate demand at the farm level is defined as the horizontal summation of derived demand for domestic consumption and derived demand for exports. Hence, the price elasticity of the aggregate demand at the farm level may be computed as a weighted sum of the price elasticities of the derived demands, where the weights are their respective market shares.

$$\hat{E}_{Y_{4\ agg}} = \alpha_d \hat{E}_{Y_4\phi} + \alpha_x \hat{E}_{Y_4X}$$

$$= (.7317)\ (-.363) + (.2683)\ (-1.195) = -.5862$$

where

$$\alpha_d = \left(\frac{\bar{Y}_3}{\bar{Y}_3 + \bar{Y}_7}\right) = \frac{1422.99}{1944.80} = .7317$$

and

$$\alpha_x = \left(\frac{\bar{Y}_7}{\bar{Y}_3 + \bar{Y}_7}\right) = \frac{521.81}{1944.80} = .2683$$

The aggregate demand at the farm level is inelastic with respect to price as indicated by the above estimate; a 10% increase (decrease) in the price at the farm level would result in approximately a 5.9% decrease (increase) in the quantity demanded at the farm level. This finding is consistent with the a priori reasoning, presented in Chapter I, that aggregate demand at the farm level is not as inelastic as it is derived demand for domestic consumption. The implications of these findings are obvious. Price variations at the farm level are not to be explained by

a highly inelastic but rather by a just somewhat inelastic aggregate demand, and by its shifts and those of the market supply.

Price Elasticity of Total Slaughter

By summing over equations (4-6) and (4-7) a function for total slaughter is obtained. The short run elasticity of slaughter with respect to price could be defined as a weighted sum of the elasticities of "steer and yearly steers' slaughter" in (4-6)ξ and of "cows, heifers, bulls and calves' slaughter" in (4-7)ρ with respect to current price.[7/]

$$E_{Y_4}(\xi + \rho) = \left(\frac{\bar{Y}_9}{\bar{Y}_9 + \bar{Y}_{10}}\right) E_{Y_4\xi} + \left(\frac{\bar{Y}_{10}}{\bar{Y}_9 + \bar{Y}_{10}}\right) E_{Y_4\rho} =$$

$$= \left(\frac{4810.76}{9095.35}\right) (.105) + \left(\frac{4284.59}{9095.35}\right) (-.112) = .003$$

It may be observed that the negative effect of current price on slaughter of "intermediate products and capital goods" (cows, heifers, bulls and calves) is compensated by the positive effect of current price on slaughter of steers and yearly steers, resulting in a very small positive value for the price elasticity of total slaughter. Although the statistical tests available are not applicable to test whether this

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[7/] Defining the elasticity of total slaughter with respect to current prices as

$$E_{Y_4(\xi+\rho)} = \left[\frac{\bar{Y}_4}{\bar{Y}_9 + \bar{Y}_{10}}\right] \cdot \left[\frac{\partial(Y_9 + Y_{10})}{\partial Y_4}\right]_{(\xi+\rho)} = \left[\frac{\bar{Y}_4}{\bar{Y}_9 + \bar{Y}_{10}}\right] \cdot \left[\left(\frac{\partial Y_9}{\partial Y_4}\right)_\xi + \left(\frac{\partial Y_{10}}{\partial Y_4}\right)_\rho\right]$$

$$= \left[\frac{\bar{Y}_9}{\bar{Y}_9 + \bar{Y}_{10}}\right] \cdot \left[\left(\frac{\bar{Y}_4}{\bar{Y}_9}\right) \left(\frac{\partial Y_9}{\partial Y_4}\right)_\xi\right] + \left[\frac{\bar{Y}_{10}}{\bar{Y}_9 + \bar{Y}_{10}}\right] \cdot \left[\left(\frac{\bar{Y}_4}{\bar{Y}_{10}}\right) \left(\frac{\partial Y_{10}}{\partial Y_4}\right)\right]$$

$$= \left[\frac{\bar{Y}_9}{\bar{Y}_9 + \bar{Y}_{10}}\right] \cdot E_{Y_4\xi} + \left[\frac{\bar{Y}_{10}}{\bar{Y}_9 + \bar{Y}_{10}}\right] \cdot E_{Y_4\rho}$$

estimate is significantly different than zero or not, it is felt that such a coefficient may in fact be zero or even negative, but that in general is very small in absolute magnitude, i.e. aggregate supply is highly inelastic with respect to current price.

The cumulative price elasticity of slaughter measured at mean values may be defined as a weighted sum of the cumulative elasticities of "steer and yearly steers' slaughter" in (4-6)ξ and of "cows, heifers, bulls, and calves' slaughter" in (4-7)ρ.[8/] The cumulative elasticity is

$$E_k^c = \left(\frac{Y_4}{Y_j}\right) \sum_{i=0}^{1} \left(\frac{\partial Y_j}{\partial Y_{4t-1}}\right); \qquad \begin{array}{l} j = 9 \text{ for } k = \xi \\ j = 10 \text{ for } k = \rho \end{array}$$

$$E_{\xi+\rho}^c = \left(\frac{\bar{Y}_9}{\bar{Y}_9 + \bar{Y}_{10}}\right) \left(\frac{\bar{Y}_4}{\bar{Y}_9}\right) \left[\left(\frac{\partial Y_9}{\partial Y_4}\right)_\xi + \left(\frac{\partial Y_9}{\partial Y_{4t-1}}\right)_\xi\right]$$

$$+ \left(\frac{\bar{Y}_{10}}{\bar{Y}_9 + \bar{Y}_{10}}\right) \left(\frac{\bar{Y}_4}{\bar{Y}_{10}}\right) \cdot \left[\left(\frac{\partial Y_{10}}{\partial Y_4}\right)_\rho + \left(\frac{\partial Y_{10}}{\partial Y_{4t-1}}\right)_\rho\right] = -\ .314$$

which indicates that a sustained increase (decrease) during two consecutive years, of a 10% in the price at the farm level will result in 3.14% decrease (increase) in the number of animals sent to slaughter.

For comparative purposes estimates obtained in other studies concerned with the Argentine beef economy are presented in Table 3.

[8/] This definition corresponds to the case where no assumption is made about the form of the distribution of the lag effect of prices in quantity supplied. Tinbergen, R., (Rotterdam), "Long-Term Foreign Trade Elasticities", Metroeconomica, December 1949, pg. 174; quoted by Nerlove, Marc, "Distributed Lags and Demand Analysis", U.S.D.A., Ag. Mktg. Service, Ag. Handbook No. 141, June 1958.

The "cumulative" adjective is not used here to characterize the total and final adjustment of slaughter to price but to distinguish this elasticity, from the elasticity of slaughter with respect to current price.

Table 3. Estimates of Short and Long Run Price Elasticity of Total Slaughter Obtained in Other Studies

	Study	period considered	nature of the model	form of the model	Elasticity short run	Elasticity long run
I	Otrera[1/]	1945-1964	simultaneous equations	linear in the variables	-2.48	-2.659*
II	Reca[2/]	1923-1947	single equation	distributed lags		- .36
III	Reca[2/]	1948-1965	single equation	distributed lags		- .21
IV	This study[3/]	1935-1966	simultaneous equations	linear in the variables	.003	- .314*

[1/] Otrera, W. R., op. cit., pp. 109-110. The estimate of the long run elasticity was computed on the basis of the information given by the author as follows:

$$e^{1}_{ms} = \left(\frac{Y_2}{Y_4}\right) \sum_{i=0}^{1} \left(\frac{\partial Y_4}{\partial Y_{2t-1}}\right)_j = \left(\frac{40.50}{95.00}\right) (-5.8157 - .4213) = -2.659$$

where Y_2 is price of beef at the farm level in 1964, and

Y_4 is the number of beef cattle slaughtered in 1964, and the jth function is "the relationship involving the number of cattle slaughtered."

[2/] Reca, L., op. cit., pp. 62-64. The estimates presented here were selected according to the definition of "best estimate" given by the author in footnote 1, page 62.

[3/] computed as in the text above.

cumulative price elasticity.

The estimate of the cumulative price elasticity of slaughter obtained in this study lies between the two estimates obtained by Reca. This is not too surprising since the sample period used in this study overlaps the periods considered by Reca.

The Stability of Equilibrium

It has been shown that a system where the demand function is steeper than the market supply with respect to the quantity axis, being both negatively sloped, is unstable in the Walrasian sense, i.e., a disturbance does not result in a return to equilibrium.[9/] It has also been shown that when supply reacts to price only after a given time lag, "if the supply curve is negatively inclined, it must be steeper referred to the quantity axis than is demand curve, precisely as in the case of Walrasian stability".[10/]

In Otrera's model the elasticity of aggregate demand at the farm level is undefined and attempts to compute one leads to a wide range of

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[9/] This condition refers to both "static and dynamic stability". Note that the consistency between static and dynamic stability depends on the coefficient of adjustment having an upper limit. See:
---Henderson and Quandt, op. cit., pp. 110-117, also
---Samuelson, "Foundations ...". op cit., pp. 258-263, and
---Christ, "Economic Models and Methods", op. cit., pp. 196-199.
Note that the literary statements and graphs do not correspond with the implications of the mathematical statements. This is probably due to typographical errors.

Samuelson comments on the Walrasian vs. Marshallian stability conditions: "A historical error is involved in the identification of the above stability conditions with Walras in alleged contrast to those of Marshall which are shortly to be discussed. Actually as far back as in Pure Theory of Foreign Trade Marshall defined stable equilibrium, in which a so-called backward rising supply curve was involved, much like the Walrasian case." Samuelson, op. cit., footnote (9), page 264.

[10/] Samuelson, "Foundations...", op. cit., pg. 265; see also Henderson and Quandt, op. cit., pp. 117-119.

estimates. The estimate of elasticity of total slaughter with respect to current price appears to be excessively large (-2.5 at 1964 values).[11] If the elasticity of aggregate demand is also negative but smaller in absolute value (and there are strong reasons to believe that such is the case) the system if taken as "the structure", is essentially unstable according to the above definition of stability. A similar statement can be made if both current prices and prices lagged one year are considered in the estimation of elasticity of slaughter supply with respect to price.

According to the estimates obtained in this study for the price elasticity of aggregate demand at the farm level (-.586) and the short and cumulative elasticities[12] of total slaughter with respect to price (+.003 and -.314) respectively, the system is essentially stable in static sense. It is also stable in dynamic sense provided that the coefficient of adjustment does not exceed the upper limit; which is likely to be the case.

It should be stressed that the market supply function is a slaughter function and not the "true supply function". This latter one is of a longer run nature (because the production process takes two years or more) and there is evidence that it is positively sloped.[13] Thus the conditions of stability will be met as long as the absolute value of the price elasticity of aggregate demand at the farm level is larger than the price elasticity of such "true supply function".[14]

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[11] Otrera, op. cit., pg. 109. The estimate computed at mean values [e_{ns} = (-5.8157) (25.15/97.305) = - 1.5] still appears to be excessively large.

[12] Recall definition of cumulative elasticity in footnote 8.

[13] See Reca, op. cit., pp. 63-64.

[14] This is a typical case of "cobweb phenomena".

In this study current annual price was postulated as being determined by the intersection of the slaughter function and the market demand function. The computed elasticities based on the estimated coefficients indicate the presence of a "stable system", i.e., the market may find its clearing price. Price fluctuations are, therefore, to be explained not in terms of a non-existing instability of the system but rather in terms of the price elasticities of both market supply and aggregate demand, and shifts of these functions arising from external factors such as exchange rate policy, export tax policy, conditions of the pastures (droughts), credit policy, etc.

Test of Economic Hypotheses

In explaining price fluctuations at the farm level it was hypothesized that (a) the very nature of the productive process was, in part, responsible for such fluctuations. The reason being that not only the production period is longer than the observation unit (the year) - which would lead to a "cobweb effect" - but also part of production may be considered capital good (heifers may be kept as breeding stock) which may transform a "cobweb effect" into a retractive process that has been called "super-cobweb effect". The findings tend to give support to this hypothesis. The negative coefficient of lagged farm price (X_{16}) in both, slaughter supply of steers and yearly steers (4-6) and slaughter supply of cows, heifers, bulls and calves (4-7) clearly indicates the presence of such phenomena. Moreover, the positive coefficient of current price (Y_4) in (4-6) versus the negative coefficient of the same variable in (4-7) indicates that cattle farmers may in fact have a different response to current market price in terms of the quantity marketed of each

category of animals, as it was hypothesized, i.e., a positively sloping slaughter function for final products but a negatively sloping slaughter function of intermediate products and capital goods.

A second hypothesis presented in Chapter I is that (b) the very nature of the demand facing the market supply was responsible for and/or contributed to the price fluctuations. The findings appear to support this hypothesis also. Aggregate demand at the farm level is inferred as being rather inelastic ($\hat{E}_{Y_4}$ agg. = 0.5862), which implies that fluctuations of slaughter may have been tracing relatively wide fluctuations in prices. Also, given that total slaughter was estimated as being highly inelastic with respect to current price [$E_{Y_4(\xi+\rho)}$ = .003], shifts in aggregate demand would result in wide price fluctuations. Moreover, if a shift in demand causes an increase (decrease) in price, such higher (lower) price would lead to a reduction (increase) of the total volume of slaughter in the next period, hence, to a still larger increase (decrease) in price.

The coefficients of the predetermined variables in equations (5-1) and (5-2) indicate that shifts in the aggregate demand at the farm level are by no means negligible, given that the variables have fluctuated within a relatively wide range as indicated by the estimates of the standard deviations of the variables presented in Table 4. In particular, the value obtained for the exchange rate elasticity of derived demand for exports [$E_{X_{15}X}$ = 1.213] is an empirical evidence that exports are not just "the residual over and above domestic consumption" but an important element in the price formation mechanism.

In summary, the hypothesis that the nature of both, slaughter supply and aggregate demand at the farm level, was responsible for the

Table 4. Means and Standard Deviations of the Variables, Sample Period 1935-1966*

Variable	Mean	Standard Deviation	Standard Deviation/mean
Y_1	8110.80	968.55	.1194
Y_2	2535.48	627.63	.2475
Y_3	1422.99	316.24	.2222
Y_4	1968.36	473.05	.2403
Y_5	3103.14	1126.99	.3632
Y_5'	5371.03	1385.51	.2579
Y_6	633.57	630.76	.1456
Y_6'	4301.80	1366.72	.3177
Y_7	5218.06	1461.11	.2800
Y_8	2202.38	754.39	.3425
Y_8'	2131.34	668.57	.3137
Y_9	4810.76	727.97	.1513
Y_{10}	4284.59	1077.19	.2514
Y_{11}	2147.74	69.34	.0323
X_1	35724.81	7586.67	.2011
X_3	1748.67	303.67	.1737
X_4	3079.81	819.80	.2662
X_5	2952.79	419.46	.1421
X_7	8346.70	1190.30	.1426
X_8	10050.90	3120.50	.3105
X_9	9261.50	3657.40	.3949
X_{10}	45290.03	5886.47	.1299
X_{12}	1032.91	274.82	.2661
X_{13}	919.14	170.65	.1855
X_{15}	5359.62	1993.05	.3719
X_{16}	1935.74	482.77	2499

*computed on the basis of the data presented in Appendix A.

fluctuations in prices; and that both derived demands - domestic and for exports - do enter the price formation process confronting the slaughter supply function of beef cattle are not rejected on the basis of the empirical evidences found in this study.

CHAPTER VI
SUMMARY AND CONCLUSIONS

General Summary

From *a priori* viewpoint, the major difference between the present study and the previous studies by Guadagni (1964), Guadagni and Petrecolla (1965), Diaz Alejandro (1964), Iver (1964) and Reca (1967) lies in the answer given to the question of whether prices and quantities should be considered as simultaneously determined or not for the specific problem under study. The major differences between this study and the previous one by Otrera (1966) arise from the questions of whether exports should be considered as "a residual over and above domestic consumption" or as playing an active role in the price formation mechanism at the farm level, whether the price received for Argentine beef exports is determined independently of the volume of exports, and whether or not such price is irrelevant in explaining the quantity exported. Otrera postulates a demand for export equation in which the quantity demanded is expressed as a function of total supply of dressed beef, domestic retail price and the Argentine population, where no role is given (neither active nor passive) to the price received for beef exports, and other exogenous factors as exchange rate. In contrast, the maintained hypothesis of the present study includes the foreign market for Argentine beef as determining its clearing price and quantity simultaneously with the domestic market. Moreover, theoretical considerations led to the

formulation of an economic model and a paralleling statistical model that differ substantially from Otrera's models in terms of the represented structures. However, it should be pointed out that this study owes a great deal to the above mentioned studies and should be considered just as an attempt to go one step forward in understanding the structure of the Argentine cattle-beef economy.

In the present study the economic problem was stated as: the need for an explanation of price fluctuations at the farm level on the basis of economic reasoning and empirical evidence. It was hypothesized that the nature of both aggregate derived demand and slaughter supply was responsible for such price fluctuations, and that both domestic demand and demand for exports enter the price formation mechanism confronting the relevant market supply function of beef-cattle at the farm level. The main objective of the study was to identify and quantify the annual structure of the Argentine cattle-beef economy, for the period 1935-1966, in a degree sufficient to provide a framework for the analysis of the causes of price fluctuations. Specific objectives were: (1) to fit and derive supply and demand relationships at different levels of the marketing channel of beef; (2) to determine the interrelationships between the domestic and the international market for Argentine beef; (3) to evaluate the impact on prices and quantities at the farm level of changes in certain variables and parameters at the retail level, the international market and exchange-rate policy; and (4) to analyze the findings in terms of the economic hypotheses and in the light of policy implications.

To meet these objectives an economic model was developed in Chapter II with a paralleling statistical model in Chapter III and the statistical

fit of the structure was presented in Chapter IV. The elasticities of derived demands, for domestic consumption and for exports, were computed in Chapter V and the stability of equilibrium was evaluated in terms of the price elasticities of aggregate demand and total slaughter supply at the farm level.

Conclusions

The low values obtained for the price elasticities of aggregate demand and slaughter supply at the farm level, and the relatively large coefficients of cross elasticities found for the slaughter supply and demand for export give empirical support to the hypothesis that the nature of both aggregate demand and slaughter supply was responsible for the wide fluctuations in price at the farm level. In particular, total slaughter supply is estimated as being highly inelastic with respect to current price, thus, it is an indication that shifts of aggregate demand at the farm level would result in wide price fluctuations. In addition, if a shift in demand causes an increase (decrease) in price, such higher (lower) price would command a lower (higher) volume of slaughter in the next period and consequently would lead to a still larger increase (decrease) in price.

The value obtained for the elasticity of export demand with respect to exchange rate indicates that the latter is a powerful shifter of demand for exports thus indicating, as it was hypothesized, that this function plays an active role in the price formation mechanism. Hence, exports of beef should not be considered just as "the residual over and above domestic consumption" as in an accounting framework but, from an economic viewpoint, should be considered as an important component of

aggregate demand at the farm level.

The hypothesis that cattle farmers have a different response to current market price in terms of the quantity marketed of each category of animals, i.e. a positively sloping slaughter function of final products but a negatively sloping slaughter function of intermediate products and capital goods, was not rejected on the basis of the empirical estimates found in this study.

Implications for Policy Making

One of the main problems faced by policy makers in general, is the lack of quantitative knowledge of the likely results of certain policy actions. Though the estimate of the structure obtained in this study does not solve such problems completely in the case of the Argentine cattle-beef economy, it at least provides a quantitative point of reference for both policy and decision making. In particular, it provides a framework for the analysis of the reasons as for why previous policy actions were or were not as effective as intended to be. Also, it is thought that the estimates of elasticity coefficients at the farm level constitute new and useful information in this context.

The empirical estimate of the structure confirms the general understanding that manipulations of the exchange rate result in shifts of the derived demand for exports, and hence in shifts of the aggregate demand at the farm level, that may lead to wide price fluctuations. Quantitative estimates of the effect of a given devaluation on prices and quantities may be obtained by rearranging the estimated structure presented in Chapter IV in an appropriate way. Similarly, an estimate of the exchange rate that would command a given volume of exports can

be found. The procedure consists in reducing the structural system to a more manageable system and rearranging the resulting equations such that the instrument variables and the remaining non-target endogenous variables are expressed as a function of the target variables and the remaining predetermined variables, which in matrix notation can be written as

$$B \cdot Z' = \Gamma Y' + M'$$

where B is a G by G matrix of the coefficients of the instrument and remaining non-target endogenous variables, Z' is a column vector of the instrument and non-target endogenous variables, Γ is a G by K matrix of the coefficients of target variables, Y' is column vector of the target variables, and M' is a column vector of data (predicted value of the remaining predetermined variables multiplied by their respective coefficients and added algebraically to the intercept); being G the number of equations remaining in the system and K the number of target variables. If the number of instrument variables equals the number of target variables and matrix B is non-singular, the solution vector is

$$Z' = B^{-1} \Gamma Y' + B^{-1} M'$$

An example of this procedure is presented in Appendix E.

At the level of the individual firms operating in the market, knowledge of the structure also represents useful information for decision making. Though an estimate of the structure is not always the best predictor, at least it provides a framework for the analysis of price and quantity reactions to specific changes in either the predetermined variables or the structural parameters, and hence, facilitates

choice among alternative decisions.

Limitations Imposed on the Estimates

As it was emphasized in Chapter IV, no claim is made that the statistical fit obtained in this study is the true structure of the annual Argentine cattle-beef economy. The methodology of statistical inference, the specific statistical procedure used in the estimation, and the specific form postulated for the model preclude making such a claim. Hence it is implied that the estimated structure is "at best" only an approximation of the true underlying structure.

The limitations imposed on the estimates arise mainly from two sources, namely, (a) appropriateness of the data used in terms of the economic variables being represented, and (b) violation of the statistical assumptions.

There is little doubt that the data used in the estimation constitute by all means only an approximation of the economic variable which each particular serie is supposed to represent. Though each serie was chosen so as to approximate as closely as possible the respective economic variable, time limitations and availability of data in many cases constrained the selection to relative gross approximations. Such is the case of initial inventory levels (X_{10}), price received for Argentine beef exports (Y_6), net price received for exports (Y_8), wages paid in the meat industry (X_5) and other variables more extensively discussed in Appendix A. In some instances, lack of availability of data led to the exclusion of the respective variable from the statistical fit, as was the case of "export duties" (retenciones) which are considered relevant in determining the net price received for exports.

A relevant question is whether the underlying structure did in fact change during the sample period. There is little doubt that the degree of interventionism during part of the period was too strong not to affect the structure. Thus, to account for such a change a dummy variable was introduced in the model. In connection with this it has been observed that the composition as well as the destiny of beef exports have been changing during the last few years and they will probably continue to do so. This being the case, one may be tempted to question the value of the knowledge of the past structure. However, as Jacob Marschak puts it:

> "whenever a given change in structure is expected or intended, the attempt to predict the outcome of alternative decisions under the new structure without taking into account experience collected under the old structure is either so lacking in precision or so wasteful of time as to be useless. It is more promising, though not always practicable, to base the choice of best policy upon an estimate of the old structure and on the knowledge of its expected or intended change."[1/]

Regarding the fulfillment of the statistical assumptions, it appears that some of them have been violated. In particular, the assumption of non-autocorrelated disturbances over time. Though the Durbin-Watson test is considered only an approximate test for the specific case under study, it does indicate the presence of positive serial correlation in the domestic demand equation, while inconclusive results are obtained from some of the other equations. In addition, the assumption that the parameters β_{ij} and γ_{ik} ($i = 1,\ldots,8$; $j = 1,\ldots,10$; $k = 0,1,\ldots,16$) are constant may have been also violated, in spite of the effort made to take into account all possible changes in the structure. Furthermore,

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[1/] Marschak, Jacob, "Economic Measurement for Policy and Prediction", in Hood and Koopmans, Studies in Econometric Methods, Cowles Commission, Monograph 14, T. Wiley & Sons, N.Y. 1953, pp. 16-17.

the implicit assumption that the variables are measured without error is clearly violated. Though the use of instrumental variables (of which 2SLS is a particular case) provides a means of by passing the problem of error of measurement, the assumption that each instrumental variable (the calculated values of Y's and the observed values of X's in the case of 2SLS procedure) is independent of each and all the errors of observations, is not fulfilled.

All these limitations should be taken into account when interpreting the results obtained in this study and when such results are used for purposes other than the specific ones of the present investigation.

Implications for Further Analysis

It seems appropriate to conclude with a summary of the potential avenues that might be profitably pursued in future research. These suggestions originate from the limitations of the present study, which were implicit or explicitly stated in the preceding discussion.

Briefly, there is a critical need to include non-traditional beef export in the analysis in a more definite way, and to evaluate its role as a component of the aggregate demand at the farm level. There is also a need to consider the interrelationships between the domestic beef market and those of its closer substitutes, namely, pork, lamb, poultry and fish. Explicit consideration of "export duties" (retenciones) would lead to a more complete model and to obtain more reliable estimates.

The results of this study further suggest that it might be desirable to specify slaughter functions for each category of beef-cattle separately and to analyze the behavior of the respective prices in such a context. The aggregate of steers and yearly steers, and of cows, heifers, bulls

and calves, though it leads to interesting conclusions in the present study, represent only a gross approximation which merits further research.

Also, it is judged that a model of a shorter run nature, i.e., on quarterly basis, may provide additional and useful information for policy and decision making by quantifying the immediate market reaction to changes in specific variables.

Finally, it can never be stressed enough that the use of more appropriate data always constitutes a step forward, and that the dynamic nature of the Argentine cattle-beef industry makes the periodical re-assessment of the model rather imperative.

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APPENDIX A

DATA USED IN THE ESTIMATION

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This appendix deals with the computation, source, and limitations of data used in the estimation of the parameters of the model. As it was stated before, each series was chosen so as to approximate as closely as possible the respective economic variable, although time limitations and availability of data in many cases constrained the selection to relative rough approximations. Such cases will be discussed here.

These data consist of time series for the period 1935-1966 and the unit of observation is the calendar year. Though the reason for choosing the calendar year as unit of observation is of a practical nature - most of the information available is published on that basis - it is judged that the problem of concern in this study can be meaningfully analyzed in such a framework.

Data on Slaughter [Y_{9t}, Y_{10t} and Y_{11t}]

Data on the total number of heads slaughtered and their average dressed weight are published by the Junta Nacional de Carnes (National Board of Meat, from now on referred as J.N.C.), and may be considered fairly reliable. These series include registered slaughter and an estimate of slaughter in-situ. Information referring to three main sub-groups of slaughter, namely, (a) steers, yearly steers, bulls, bullocks and oxen; (b) cows and heifers; and (c) calves, are also published by J.N.C.

Table 5. Data on Registered Slaughter of Steers, Yearly Steers, Bulls, Bullocks and Oxen, and on Slaughter In-Situ, Period 1935-1966.

Years	[1] Registered Slaughter of Steers, Yearly Steers, Bulls, Bullocks and Oxen[1]*	[2] Registered Slaughter of Bulls, Bullocks and Oxen[2]*	[3] Registered Slaughter of Steers and Yearly Steers[3]*	[4] Slaughter in-situ[1]*	[5] Porportion of Steers and Yearly Steers on Total Registered Slaughter[3]
1935	3727605	52470	3675135	645182	.57435
1936	3579568	68197	3511371	649991	.52170
1937	3917511	82493	3835018	687094	.53555
1938	3701344	76303	3625041	704271	.51278
1939	3964245	81509	3882736	713891	.52078
1940	3697785	81400	3616385	704271	.51783
1941	4332147	94424	4237723	697400	.55919
1942	3970984	104197	3866787	563106	.54174
1943	3537623	106370	3431253	528408	.51229
1944	3882074	99800	3782274	567900	.58010
1945	3528271	88440	3439831	608763	.57573
1946	3755863	95062	3660801	730515	.50941
1947	4509002	139754	4369248	673535	.50031
1948	4410393	126323	4284070	606451	.49833
1949	4679341	120643	4558698	549600	.51045
1950	4710601	139466	4571135	501400	.48647
1951	4418915	137231	4281684	503500	.50524
1952	4374817	121915	4252902	557600	.51687
1953	4567277	120598	4446679	633100	.61224
1954	5107856	132123	4975733	539100	.65522
1955	5438705	157806	5280899	543800	.55823
1956	6063505	295000	5768505	482600	.51589
1957	5721369	192000	5529369	425000	.47929
1958	6119112	257000	5862112	400000	.49387
1959	5051539	169000	4882539	400000	.55823
1960	4950753	160000	4790753	424460	.56634
1961	5279890	205000	5074890	400000	.51730
1962	5612758	251000	5361758	400000	.45459
1963	6167934	271000	5896934	350000	.46886
1964	5368872	239000	5127872	360000	.56928
1965	5451955	234000	5217955	375000	.59562
1966	5850000	247000	5603000	375000	.51791

[1] Source: J.N.C., Reseña 1966 pg. 15 and 24.

[2] Source: Direccion General de Economia Agropecuaria del Ministerio de Agricultura y Ganaderia, quoted by J.N.C. Reseña 1957, 1965 and 1966.

[3] Computed as indicated in the text.

*Number of heads

Table 6. Data on Slaughter of Steers and Yearly Steers [Y_9], on Slaughter of Cows, Heifers, Bulls and Calves [Y_{10}] and on Average Weight of Slaughtered Animals [Y_{11}], Period 1935-1966

Years	[1] Total Slaughter of Steers and Yearly Steers 2/	[2] Total Slaughter of Cows, Heifers, Bulls and Cows 2/	[3] Total Slaughter 1/	[4] Output of Dressed Beef from Slaughter 1/	[5] Average Dressed Weight of Slaughtered Animal 2/
	(# of heads)	(# of heads)	(# of heads)	(tons)	(kgs. per head)
1935	4045695	2998241	7043936	1532060	217.501
1936	3850471	3530101	7380572	1583279	214.520
1937	4202991	3645020	7848011	1725042	219.806
1938	3986228	3787440	7773668	1690154	217.420
1939	4254516	3914953	8169469	1806457	221.123
1940	3981078	3706891	7687965	1690113	219.839
1941	4627702	3647942	8275644	1854029	224.033
1942	4171844	3529007	7700851	1724884	223.986
1943	3701951	3524378	7226329	1602635	221.777
1944	4111713	2976248	7087961	1619386	228.470
1945	3790314	2793213	6583527	1455721	221.116
1946	4032933	3883925	7916858	1682164	212.479
1947	4706224	4700413	9406637	2023811	215.147
1948	4586283	4616990	9203273	1958136	212.765
1949	4839241	4641105	9480346	2003202	211.301
1950	4815051	5082848	9897899	2043954	206.504
1951	4536072	4441931	8978003	1879360	209.329
1952	4541109	4244604	8785713	1788170	203.532
1953	4834288	3061763	7896051	1765513	223.594
1954	5328962	2804171	8133133	1814909	223.150
1955	5584464	4419424	10003888	2146854	214.602
1956	6017473	5646860	11664333	2475582	212.235
1957	5733163	6228579	11961742	2459455	205.610
1958	6063660	6214087	12277747	2540898	206.952
1959	5105831	4042419	9148250	1944433	212.547
1960	5031141	3852486	8883627	1892830	213.070
1961	5282810	4929455	10212265	2145064	210.048
1962	5543594	6246869	11790463	2378826	201.759
1963	6061035	6865427	12926462	2605287	201.547
1964	5332813	4034772	9367585	2019240	215.556
1965	5440312	3693561	9133873	1995096	218.428
1966	5803216	5401784	11205000	2387000	213.030

1/ Source: J.N.C., Reseña 1966, pg. 15 and 24.

2/ Computed as indicated in the test on the basis of the information presented in Table 5.

In order to approximate the variables as defined in the theoretical model it was necessary to substract from (a), the number of bulls, bullocks and oxen slaughtered and to add an estimate of the slaughter in-situ of steers and yearly steers. To compute this latter estimate it was assumed that the proportion of steers and yearly steers slaughtered in-situ was the same as the proportion of steers and yearly steers on total registered slaughter. Data used to estimate total slaughter of steers and yearly steers are presented in Table 5. The data on slaughter [Y_9 and Y_{10}] and on average weight [Y_{11}] used in the estimation are shown in Table 6, columns [1], [2] and [5] respectively.

Data on Beef Consumption and Exports [Y_{1t}, Y_{3t}, Y_{5t}, and Y_{7t}]

These data refer to the dressed weight equivalent of animals bought by the marketing group and by export-packers for domestic consumption and for exports respectively. As it was explained in Chapter II, the actual volume of beef exports does not coincide exactly with the dressed equivalent of the animals bought by export-packers. There appears to be two main reasons for such discrepancy, (1) some of the beef is processed for export (i.e., frozen-deboned feed, canned beef, cooked and frozen, etc....) and losses of weight occur which cannot be taken into account with available information, and (2) the shipping space available in the short run did not always match the plans of export-packers.

Because there is no direct observation of the quantity sold in the domestic retail market, the volume bought by the marketing group for domestic consumption is taken as the actual volume of consumption, and hence, it is implicitly assumed that if there exists a loss weight in the

Table 7. Total and Per-capita Domestic Consumption of Beef [Y_3 and Y_1 respectively], Dressed Equivalent Volume of Animals Bought for Exports [Y_7], Volume of Refrigerated Beef Exports [Y_5] and Volume of Total Beef Exports [Y_5'] for the Period 1935-1966

Years	[1] Total Domestic Consumption 1/ (tons)	[2] Pop. at June 30 2/ (1000 inhabitants)	[3] Per-capita Consumption 3/ (kgs. per capita)	[4] Beef Bought for Exports 4/ (tons)	[5] Exports of Refrigerated Beef 5/ (tons)	[6] Total Exports of Beef 6/ (tons)
1935	1008022	13043.8	77.280	524038	379182	579245
1936	996361	13259.8	75.141	586918	397124	611286
1937	1066171	13490.1	79.034	658871	441594	671133
1938	1080963	13724.5	78.762	609191	445100	668272
1939	1106517	13947.6	79.334	699940	464000	709110
1940	1094638	14169.2	77.255	595475	373600	607743
1941	1101733	14401.5	76.501	752296	372700	728459
1942	1022653	14637.5	68.499	722231	373300	691110
1943	971536	14877.4	65.303	631099	294800	570272
1944	1020323	15129.5	67.439	599063	293200	619611
1945	1081944	15390.0	70.302	373777	175200	339737
1946	1239283	15653.6	79.169	442881	225700	423960
1947	1380779	15927.4	86.692	643032	338000	597561
1948	1486616	16268.3	91.381	471520	277400	470992
1949	1536126	16656.2	92.225	467076	318424	519471
1950	1614505	17069.9	94.582	429449	171053	368547
1951	1623377	17480.8	92.866	255983	109857	382123
1952	1512675	17858.6	84.703	275495	96808	252353
1953	1535226	18202.3	84.342	230287	112772	271598
1954	1583493	18543.5	85.393	231416	104732	326914
1955	1731897	18893.0	91.669	414957	189809	429454
1956	1873313	19250.2	97.314	602269	320300	583023
1957	1873529	19614.5	95.518	585926	327383	672624
1958	1893824	19979.5	94.788	647074	343792	704790
1959	1427485	20324.7	70.234	516948	344962	545211
1960	1507858	20669.0	72.953	384972	280047	428964
1961	1748961	21011.0	83.240	396103	270706	456092
1962	1833576	21350.0	85.882	545250	388692	558959
1963	1873710	21688.0	86.394	731577	531526	772549
1964	1434733	22019.0	65.159	584507	420902	575788
1965	1492915	22352.0	66.791	502181	349190	473481
1966	1801000	22691.0	79.371	586000	398190	576881

1/ Source: Junta Nacional de Carnes (J.N.C.), Reseña 1966, pg. 188.

2/ Source: Direccion Nacional de Estadistica y Censos, quoted by J.N.C., Reseña 1966, pg. 188.

3/ Obtained by dividing column [1] by column [2].

4/ Source: J.N.C., Reseña 1966, pg. 11.

5/ Source: Ministerio de Hacienda de la R. A., "Anuario Comercio Exterior" several issues. The period 1938-1948 from Anuario Estadistico de la R, A., Tomo 1, Compendio 1948.

6/ Source of data for the period 1935-1954: Ministerio de Hacienda, "Anuario Comercio Exterior", several issues, for the period 1955-1966: computed on the basis of information from J.N.C., Reseña, several issues. See Reseña 1966, pg. 199.

process, such loss is a proportion that has remained constant throughout the sample period. Furthermore, it is assumed that demand for and supply from cooling storage is negligible, which does not appear to be a very unrealistic assumption given the limited availability of cooling capacity.

Data on total [Y_3] and per-capita [Y_1] domestic consumption of beef, dressed equivalent volume of animals bought for exports [Y_7], actual volume of refrigerated beef exports [Y_5] and volume of total beef exports [Y_5'] for the period 1935-1966 are presented in columns [1], [3], [4], [5] and [6] of Table 7, respectively.[1/]

Data on Retail and Farm Level Prices [Y_{2t} and Y_{4t}]

The prices used in this study as "farm level prices" (Y_4) are annual average prices at the Central Market of Liniers. Because more than 30% of the beef-cattle for slaughter is marketed through this particular market,[2/] and because the computed prices are considered to be fairly accurate, it is felt that they approximate relatively close the economic concept being represented. Moreover, prices at Liniers' Market are daily reported by newspapers, radio networks and in special bulletins published by J.N.C., and hence, it may be assumed that if the difference in price

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[1/] Under refrigerated beef it is included only chilled beef, frozen beef and frozen "M" (manufactured). Under total beef exports it is included refrigerated beef, salted beef, cooked and frozen beef, frozen meat ofal, frozen and preserved tongues, and canned beef. The volume of exports of canned beef has been multiplied by 2.5 because: "it is estimated that in order to export one ton of canned beef, it is necessary to use more or less two and a half tons of dressed beef", Otrera, op. cit., pp. 61-63.

[2/] In the average, for the period 1935-1966, 35% of the beef-cattle for slaughter has been marketed through central markets (of which Liniers represents about 90%), 25% has been sold on farms, 23% was sold in local auctions, and 17% was sold on farm to local packers.

with other markets exceeds transportation and related costs, more cattle would flow towards this market. If this is the case, annual average prices at Liniers would in fact reflect the overall price level of the country.

An important factor in the computation of a price index is not only how accurate the prices are, but also how appropriate are the weights utilized in its computation in relation to the concept the particular index is trying to represent. The information on hand at the time of writing these pages does not permit an evaluation on these lines. Further studies should emphasize the use of appropriate weights.

The prices at the farm level, as published, are prices per-kg of alive animal. To transform these prices into dressed beef equivalent, a dressing percentage of .57 has been used.

The data used in this study as price of the retail level (Y_2) is an average price of five main cuts of beef obtained from a sample of retail stores in the Federal District.[3/] Though the coverage of the sample does not permit the generalization of this price for the country as a whole, it is felt that due to the fact that the Federal District and the metropolitan area (Great Buenos Aires) share about 40% of total domestic consumption, given the specific objectives of this study, the data on retail prices approximate relatively close the concept being represented.

The price at the retail level (Y_2) and the price at the farm level (Y_4) expressed in constant money are presented in columns [3] and [5] of Table 8, respectively.

[3/] See: Qtrera, op. cit., pp. 64-66.

Table 8. Prices of Beef at the Retail [Y_2] and Farm Level [Y_4] and Cost of Living Index in Argentina for the Period 1934-1966

Years	[1] Retail Price (current pesos per kg.)[1/]	[2] Cost of Living Index (Jan. 1960 = 100)[1/]	[3] Retail Price (pesos of 1960 per kg.)[2/]	[4] Farm Price (pesos per kg. alive animal)[1/]	[5] Farm Price (pesos of 1960 per kg. of dressed weight)[3/]
1934	.	2.173		.160	12.921
1935	.57	2.303	24.750	.200	15.241
1936	.65	2.498	26.021	.220	15.449
1937	.62	2.564	24.181	.220	15.050
1938	.61	2.547	23.949	.210	14.467
1939	.62	2.587	23.966	.230	15.595
1940	.65	2.645	24.575	.250	16.576
1941	.67	2.715	24.678	.280	18.095
1942	.73	2.869	25.444	.350	21.413
1943	.76	2.901	26.198	.350	21.169
1944	.81	2.892	28.008	.380	23.044
1945	.85	3.463	24.545	.377	19.096
1946	.90	4.075	22.086	.385	16.576
1947	.95	4.627	20.532	.478	18.123
1948	.95	5.233	18.154	.527	17.666
1949	1.15	6.860	16.764	.619	15.829
1950	1.40	8.612	16.256	.720	14.666
1951	2.15	11.771	18.265	1.154	17.200
1952	3.56	16.328	21.803	1.621	17.418
1953	4.00	16.978	23.560	1.937	20.018
1954	4.00	17.622	22.699	2.000	19.913
1955	4.00	19.792	20.210	2.000	17.730
1956	4.00	22.446	17.821	2.280	17.822
1957	6.00	27.995	21.432	2.518	15.780
1958	8.50	36.836	23.075	4.041	19.243
1959	29.80	78.717	37.857	14.060	31.336
1960	34.38	100.202	34.311	15.150	26.525
1961	33.32	113.737	29.296	13.780	21.256
1962	40.37	145.651	27.717	16.080	19.323
1963	52.47	181.064	28.979	23.250	22.528
1964	83.00	221.147	37.532	40.510	32.137
1965	120.00	284.373	42.198	50.620	31.229
1966	129.36	375.056	34.491	49.940	23.360

1/ Source: Junta Nacional de Carnes, Reseña 1966, p. 190.

2/ Computed by dividing column [7] by column [2].

3/ Computed by deflating current prices (column [4]) by the C.L.I. (column [2]) and by dividing by .57 (dressing percentage).

Data on Export Prices and Exchange Rate [Y_{6t}, Y_{8t} and X_{15t}]

The limited information available on quantity and prices of specifi beef product exported led to the use of simple weighted averages (i.e., value/volume) as price of exports (Y_6) and net price received for export: (Y_8). As it was pointed out in Chapter IV, an average price computed in such a way is subjected to biases if the composition of exports did chan during the sample period.[4/]

Because the composition of "refrigerated beef exports" has been more stable than the composition of "total beef exports", the estimates of the structure obtained by using the average prices of refrigerated beef exports are considered more reliable than those obtained by using the average prices of total beef exports.

Data on dollar value and volume of refrigerated and total beef exports are presented in Table 7. Since the resulting average prices are expressed in current dollars, to be consistent with the rest of the variables in the "foreign demand for Argentine beef" which are expressed in constant money it was necessary to deflate them. The particular deflator

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[4/] This can be seen by examining the way in which the index is computed.

$$W_{Q_t}(P_t) = \frac{\text{value}}{\text{volume}} = \frac{\sum_i Q_{it} P_{it}}{\sum_i Q_{it}} = \sum_i \frac{Q_{it}}{\sum_i Q_{it}} \cdot P_{it} = \sum_i q_{it} P_{it}$$

where q_{it} is the proportion of ith beef product relative to the total volume of beef exports during year t. It is evident that the average price defined in this way [$W_{Q_t}(P_t)$] will change whenever either some price (P_{it}) changes or some weight (q_{it}) changes, or both. Because the interest here lies on the measurement of changes in prices (P_i's) only, changes in composition of exports (q_i's) would introduce a bias in the index as computed by $W_{Q_t}(P_i)$.

used was the Retail Price Index of the United Kingdom (1960 = 100), from now on referred as R.P.I. (U.K., 1960 = 100).

The value of exports (in pesos) for a given year was obtained by multiplying the dollar value of exports times the average rate of exchange (pesos per dollar) at which export-packers during that particular year were able to sell their export earnings. The net price received for exports was computed as simple weighted average (value of exports in pesos/volume). Again, to be consistent with all prices and income variables in the domestic sector expressed in constant money, it was necessary to deflate this average price by the C.L.I. of Argentina (January 1960 = 100).

To maintain the validity of the "international domestic price transformation identity" (3-10) the current exchange rate was deflated by an implicit price deflator constructed as follows:

$$IPD = \frac{RPI_{UK}}{CLI_{Arg}}$$

where IPD : implicit price deflator

RPI_{UK} : retail price index of United Kingdom, 1960 = 100

CLI_{Arg}: cost of living index of Argentina, Jan. 1960 = 100.

By using this deflator the identity (3-10) is maintained for every set of observations, (i.e., for every year) as may be seen next.

$$\frac{p_t^x}{CLI_{Arg\ (1960=100)}} = \frac{p_t^{ia}}{RPI_{UK\ (1960=100)}} \cdot \left[Exr_t \cdot \frac{RPI_{UK\ (1960=100)}}{CLI_{Arg(1960=100)}} \right]$$

$$Y_{8t} = Y_{6t} \cdot Y_{15t}$$

Table 9. Current Average Exchange Rate for Beef-Exports and Average Exchange Rate in Constant Money [X_{15}] for the Period 1935-1966

Years	[1] Current Average Exchange Rate (pesos per dollar)[1]	[2] RPI_{UK} (1960=100)[2]	[3] CLI_{Arg} (Jan. 1960 = 100)[3]	[4] Average Exchange Rate (pesos of 1960 per dollar of 1960)[4]
1935	2.826	33.46	2.303	41.059
1936	2.937	34.45	2.498	40.504
1937	3.012	35.43	2.564	41.621
1938	3.051	36.42	2.547	43.627
1939	3.183	37.40	2.587	46.016
1940	3.358	42.32	2.645	53.728
1941	3.358	46.26	2.715	57.216
1942	3.358	49.21	2.869	57.597
1943	3.358	51.18	2.901	59.242
1944	3.358	52.17	2.892	60.576
1945	3.358	54.13	3.463	52.489
1946	3.358	56.10	4.075	46.229
1947	3.358	59.06	4.627	42.862
1948	3.358	62.99	5.233	40.420
1949	3.358	64.96	6.860	31.798
1950	3.910	66.93	8.612	30.387
1951	4.935	73.82	11.771	30.949
1952	4.935	79.72	16.328	24.095
1953	4.935	82.68	16.978	24.033
1954	4.935	83.66	17.622	23.429
1955	7.280	87.60	19.792	32.221
1956	18.000	92.13	22.446	73.881
1957	18.000	95.57	27.995	61.449
1958	24.410	98.43	36.836	65.226
1959	78.000	99.01	78.717	98.108
1960	82.650	100.00	100.202	82.483
1961	82.610	103.44	113.737	75.130
1962	114.920	107.78	145.651	85.038
1963	137.780	109.94	181.064	83.657
1964	139.390	113.48	221.147	71.527
1965	168.000	118.89	284.373	70.236
1966	207.050	123.62	375.056	68.244

1/ Source: International Monetary Fund, "International Finantial Statistics", several issues.

2/ Source: Her Majesty's Stationery Office, "Annual Abstract of Statistics", several issues.

3/ Source: J.N.C., Reseña 1966, pg. 190.

4/ Computed as indicated in the text.

Table 10. Value, Volume and Average Price of Refrigerated Beef Exports, for the Period 1935-1966

Year	[1] Volume (tons)[1/]	[2] Value (100 dollars)[1/]	[3] Average Price per Ton (dollars)[2/]	[4] Average Price per Ton (dollars of 1960)[2/]	[5] Average Net Price Received for Exports (pesos of 1960 per 100 kgs)[2/]
1935	379182	596603	157.3	470.1	1930.2
1936	397124	609125	153.4	445.3	1803.6
1937	441594	661023	149.6	422.2	1757.4
1938	445100	655523	147.3	404.4	1764.5
1939	464000	653157	140.8	376.5	1732.4
1940	373600	557475	149.2	352.8	1894.2
1941	372700	601251	161.3	346.7	1995.0
1942	373300	774270	207.4	421.5	2427.5
1943	294800	636093	215.8	421.6	2498.0
1944	293200	657534	224.3	429.9	2604.4
1945	175200	395771	225.9	417.3	2190.5
1946	225700	539607	239.1	426.2	1970.3
1947	338000	829065	245.3	415.3	1780.2
1948	277400	752829	271.4	430.9	1741.6
1949	318424	1201839	377.4	581.0	1847.4
1950	171053	477010	278.9	416.7	1266.3
1951	109857	407968	371.4	503.1	1557.1
1952	96808	365183	377.2	473.2	1140.1
1953	112772	475637	421.8	510.2	1226.1
1954	104732	482914	461.1	551.2	1291.3
1955	189809	819210	431.6	492.7	1587.6
1956	320300	1110328	346.7	376.3	2460.2
1957	327383	1093368	334.0	349.5	2025.0
1958	343792	1293220	376.2	382.2	2442.9
1959	344962	1458934	422.9	427.1	3710.7
1960	280047	1246083	444.9	444.9	3414.8
1961	270706	1106677	408.8	395.2	3673.6
1962	388692	1367908	351.9	326.5	2790.9
1963	531526	2030013	381.9	347.4	2905.9
1964	420902	2242944	532.9	496.6	3358.8
1965	349190	2283339	653.9	550.0	3863.0
1966	398190	2401938	603.2	487.9	3330.1

1/ Source: Ministerio de Hacienda, "Anuario Comercio Exterior", several issues; and Anuario Estadistico de la Republica Argentina Compendio 1948, Tomo 1.

2/ Computed as indicated in the text above.

Table 11. Value, Volume and Average Price of Total Beef Exports for the Period 1935-1966

Year	[1] Volume (tons)[1/]	[2] Value (100 dollars)[1/]	[3] Average Price per Ton (dollars)[2/]	[4] Average Price per Ton (dollars of 1960)[2/]	[5] Average Net Price Received for Exports (pesos of 1960 per 100 kgs.)[2/]
1935	579245	714434	123.3	368.5	1674.1
1936	611286	727531	119.0	345.4	1399.3
1937	671133	836806	124.7	352.0	1465.3
1938	668272	865293	129.5	355.6	1551.0
1939	709110	878894	123.9	331.3	1525.0
1940	607743	765807	126.0	297.7	1560.0
1941	728459	923693	126.8	274.1	1567.5
1942	691110	1249488	180.8	367.4	2116.1
1943	570272	1174515	206.0	402.5	2384.0
1944	619611	1242999	200.6	384.5	2329.4
1945	339737	708463	208.5	385.2	2022.1
1946	423960	931015	219.6	391.4	1809.6
1947	597561	1407037	235.5	398.7	1708.9
1948	470992	1314023	279.0	442.9	1790.3
1949	519471	1605718	309.1	475.8	1513.1
1950	368547	1059642	290.7	434.3	1305.6
1951	382123	1632855	427.3	578.8	1791.5
1952	252353	1425923	565.3	709.1	1707.8
1953	271598	1947112	716.9	867.1	2088.2
1954	326914	2260070	691.3	826.3	1936.1
1955	429454	1545300	359.8	410.7	1323.3
1956	583023	1931100	331.2	359.5	2350.6
1957	672624	2125900	316.1	330.7	1916.4
1958	704790	2534300	359.5	365.3	2334.9
1959	545211	2268100	416.0	420.2	3650.0
1960	628964	1771890	413.1	413.1	3046.6
1961	456092	1822100	399.5	382.6	2688.9
1962	558959	2111900	377.8	350.5	2981.2
1963	772549	2847200	368.5	335.2	2804.2
1964	575788	2943300	511.1	450.4	3221.6
1965	473481	2834100	598.5	503.4	3536.0
1966	576881	3202000	555.1	449.0	3064.2

[1/] Source: (1935-1954) Ministerio de Hacienda, "Anuario Comercio Exterior", several issues; (1955-1966) Computed on the basis of information from J.N.C., Reseña, several issues (see Reseña 1966, p. 199).

[2/] Computed as indicated in the text.

The current exchange rate (simple annual average) and exchange rate in constant money [X_{15t}] are presented in columns [1] and [4] respectively of Table 9.

Data on export price (in constant dollars) [Y_{6t}] and on the net price received for exports (in constant pesos) [Y_{8t}] are shown in columns [4] and [5] respectively of Table 10 (refrigerated beef exports) and Table 11 (total beef exports).

Data on Size of the Herd [X_{10t}]

Direct information on the number of animals on farms at the beginning of the year is not available for the complete period. The census information corresponds to the years 1930, 1937, 1947 and 1960, and there exist estimations for the years 1953 through 1966.

Data on beginning inventory (X_{10t}) used in this study are estimates generated by Reca.[5/] Reca computed a "natural rate" of growth of the cattle herd for the inter-census period by using the following formula:

$$I_{t+n} = I_t (1 + r)^n - \sum_{i=1}^{n} S_{t+i-1} (1 + r)^{n-i}$$

where I_t = inventory at the beginning of year t.

r = average annual rate of growth of the herd for the inter-census period.

S_t = number of heads slaughtered during year t.

Once the rate of growth "r" was determined, estimates of size of the herd I_t for a given year t were generated by means of the identity:

[5/] Reca, Lucio G., op. cit., pp. 6-7, and 128-130.

$$I_{t+1} = H_t (1 + r) - S_t$$

The assumptions underlying this computational procedure are rather strong. As Reca puts it:

> "This procedure, which is an approximation, assumes that the composition of the stock has not changed through time. It also assumes that production takes place at one moment in time, while on the other hand, slaughter occurs throughout the year."[6/]

A word of warning is in order: the estimates of the structure and in particular, the estimate of the coefficient of the inventory variable (X_{10t}) in the slaughter equations should be interpreted with caution precisely because the data on inventory used in the estimation represent only a rough approximation of the true values.[7/]

Data used in this study and computed as indicated above are presented in columns [1] of Table 12.

Data on Income per-Capita [X_{1t}]

No information on disposable income per-capita is available for the complete period. Moreover, no information on Net National Product (NNP) is available from a single source for the whole period. The procedure used here to couple the series from different sources is similar to that

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[6/] Reca, Lucio G., op. cit., pp. 6-7.

[7/] For a more extensive discussion of the limitations imposed on the model by using inventory data generated in the above way, see: Jarvis, Lovell, "A Macro Model of the Beef Cattle Sector in Argentina", unpublished paper presented at the "Seminario Interno del Centro de Investigaciones Economicas (ITDT), Buenos Aires, June 21, 1968.

used by Guadagni and Petrecolla.[8/] Essentially, for the period 1935-1949, data on NNP in pesos of 1960 were obtained from data published by the Secretary of Economic Affairs,[9/] interpolating linearly the years 1944-1949 to couple with data for 1950-1961 published by Conade-Cepal.[10/] Data on NNP in pesos of 1960 for the period 1962-1966 were obtained by extrapolation on the basis of data on Gross Domestic Product (GDP) in pesos of 1960 published by the Central Bank (BCRA)[11/] for the same period. Data in current values were deflated in all cases by using the corresponding index of implicit prices. These data are presented in column [2] of Table 12.

Data on Prices of by-products [X_{4t}]

Since hides constitute the main by-product obtained from beef-cattle slaughter, prices of hides were used to represent this variable. Data used correspond to average prices of salted beef-cattle hides published by the Direccion Nacional de Estadistica y Censos.[12/] The series was deflated by the CLI (Jan. 1960 = 100) and is presented in column [3] of Table 12.

[8/] Guadagni and Petrecolla, op. cit., p. 286.

[9/] Secretaria de Asuntos Economicos, "Producto e Ingreso de la Republica Argentina", 1952.

[10/] CONADE, "Cuentas Nacionales de la Republica Argentian, 1950-1961".

[11/] Banco Central de la Republica Argentina, "Boletin Estadistico", February 1968, p. 46.

[12/] Direccion Nacional de Estadistica y Censos, "Boletin de Estadistica", several issues.

Data on Wages Paid by Intermediaries and Packers [X_{5t}]

Information on wages paid in the meat industry is available since 1949. The information for the period 1935-48 is scarce and incomplete. The variable used as proxy for wages paid by intermediaries and packers [X_{5t}] is an index of industrial real wages for the Federal District[13/] shown in column [4] of Table 13. It should be pointed out that the zero order correlation coefficient between both series for the known period (1949-1966) is .994.[14/]

The index of industrial wages was computed as the arithmetic mean of the wages paid to specialized and non-specialized labor[15/] in the industrial sector of the Federal District. The Cost of Living Index (Jan. 1960 = 100) was used to express this series in constant money.

Data on Price of Substitutes of Argentine Beef [X_7]

In the average, about 80% of refrigerated beef exports were shipped to England during the period 1935-1966. The data used in this study to represent the price of substitutes of Argentine beef in the international market correspond to an average price of beef-cattle in England as

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[13/] At first, an attempt was made to extrapolate the series on wages paid by the meat industry by using the information on industrial real wages. However, the observations to be extrapolated (14 observations) were too many for this method to yield acceptable results. See: Friedman Milton, "The Interpolation of Time Series by Related Series", Journal of American Statistical Association, December 1962, pp. 729-757.

[14/] However, it should be stressed that the correlation coefficient between the "deviation from trend" of both series is also important in these cases.

[15/] These wages as published by the Direccion Nacional de Estadistica y Censos are geometric averages of the wages paid in twelve industries excluding the meat industry.

Table 12. Data on Size of the Herd [X_{10}], Per-capita Net National Income [X_1], and Price of Beef-Cattle Hides, for the Period 1935-1966

Year	[1] Size of the Herd (1000 heads)[1/]	[2] Per-capita Net National Income (pesos of 1960)[2/]	[3] Price of Salted Beef-Cattle Hides (pesos of 1960 per 100 kgs)[3/]
1935	37286.9	23356	3126
1936	37249.2	24749	3203
1937	36867.7	27076	3861
1938	37325.8	25293	3788
1939	37636.8	25644	3054
1940	37619.4	25150	3062
1941	38079.9	26967	3499
1942	38052.4	27340	3695
1943	38593.7	26878	3654
1944	39726.8	24084	3665
1945	41243.7	29662	3061
1946	43593.5	34374	3780
1947	45118.9	39661	4647
1948	45089.5	42889	4128
1949	45440.7	40157	3619
1950	45589.2	38941	4087
1951	45351.6	38809	4375
1952	45983.6	35722	2468
1953	46941.8	37547	2374
1954	48992.8	38897	2287
1955	51241.3	41222	2036
1956	52095.5	39797	2348
1957	51470.2	40502	2672
1958	50415.0	43512	2899
1959	48820.2	41028	4215
1960	50017.0	41688	2579
1961	51883.5	42758	2178
1962	52774.4	43441	2451
1963	52277.7	41260	1944
1964	50538.7	43930	1664
1965	51986.2	47072	1938
1966	53977.3	43788	2197

1/ Source: Reca, Lucio G., op. cit., pp. 129-130. Since 1960 the series was re-estimated by using an average rate of growth of the cattle herd r = .214 and revised figures of slaughter.

2/ Source: As indicated in the text.

3/ Source: D.N.E.C., "Boletin de Estadistica", several issues.

Table 13. Data on Industrial Wages in the Federal District [X_5], for the Period 1935-1966

Year	[1] Average Wage for Specialized Labor	[2] Average Wage for Non-Specialized Labor	[3] Average Wage for Specialized and Non-Specialized Labor	[4] Average Wage for Specialized and Non-Specialized Labor
	(pesos x hour)[1]	(pesos x hour)[1]	(pesos x hour)[2]	(pesos of 1960 x hour)[3]
1935	.84	.53	.685	29.744
1936	.86	.55	.705	28.223
1937	.89	.56	.725	28.276
1938	.89	.56	.725	28.465
1939	.92	.57	.745	28.798
1940	.93	.57	.750	28.355
1941	.94	.62	.780	28.792
1942	.98	.62	.800	27.884
1943	1.03	.68	.855	29.472
1944	1.08	.73	.905	31.293
1945	1.20	.80	1.000	28.877
1946	1.33	.91	1.070	26.258
1947	1.73	1.17	1.450	31.334
1948	2.32	1.67	1.995	38.123
1949	2.93	2.08	2.505	36.516
1950	3.48	2.55	3.015	35.009
1951	3.96	3.04	3.500	29.734
1952	5.13	3.90	4.515	27.652
1953	5.37	4.07	4.720	27.801
1954	6.04	4.77	5.405	30.672
1955	6.17	4.91	5.540	27.991
1956	8.68	6.72	7.700	34.274
1957	8.90	6.89	7.895	28.201
1958	13.05	10.13	11.590	43.188
1959	21.78	17.19	19.485	24.753
1960	25.47	20.28	22.875	22.829
1961	32.18	25.17	28.675	25.212
1962	40.30	31.46	35.880	24.634
1963	50.36	39.37	44.865	24.779
1964	65.22	51.94	58.580	26.489
1965	103.70	70.62	87.150	30.681
1966	136.00	94.17	115.085	30.685

[1] Source: D.N.E.C., "Boletin de Estadistica", several issues. Years 1935-1937 extrapolated on the basis of an index of real wages (1929 = 100) for the Federal District and the C.L.I. (1929 = 100) published by the Comite Nacional de Geografia, in "Amuario Geografico Argentino 1941, pp. 555 and 557.

[2] Arithmetic Mean of column [1] and [2].

[3] Column [3] deflated by the C.L.I. (Jan. 1960 = 100).

published by F.A.O.[16] These prices were transformed to a dressed-weight equivalent by assuming a dressing percentage of .60 and were deflated by the R.P.I. (UK, 1960 = 100); they are presented in column [1] of Table 14.

Index of Real Income of Importing Countries [X_8]

Real Net National Incomes (in dollars of 1960) were computed for the major importing countries: United Kingdom, Italy, Spain and Germany. Each individual series was transformed to an index 1955 = 1000. The series used in this study to represent the real income of importing countries [X_{8t}] was computed as follows: for the period 1935 to 1954 the index corresponding to the United Kingdom was taken, and for the period 1955-1966, the arithmetic mean of the indexes corresponding to United Kingdom, Italy, Spain and Germany. The reason for including these other countries in the index from 1955 thereon is that United Kingdom's share of Argentine refrigerated beef exports began to decline[17] notoriously since 1955 in favor of Italy, Spain and Germany.

The basic information for constructing the index for each country was taken from: (a) U.N., "Statistical Yearbooks" 1949-50 through 1966 issues; (b) U.N., "Monthly Bulletin of Statistic", May 1968; (c) Her majesty's Stationery Office, "Annual Abstract of Statistic", 1954 through 1967 issues; and (d) Her Majesty's Stationery Office, "Monthly Digest of Statistic", several issues.

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[16] F.A.O., "Trade Yearbook", several issues. It should be pointed out that this series is not by all means an homogeneous series and there are possibilities of obtaining more appropriate ones if time limitations are circumbended.

[17] See Banco Ganadero Argentino, op. cit., Table 15, p. 54.

The index of real income of importing countries computed as indicated above is presented in column [2] of Table 14.

Data on Availability of Shipping Space [X_9]

As a proxy for shipment capacity, information on the volume loaded on vessels in Buenos Aires' docks was used. This information, published by United Nations,[18/] refers to sea-born shippings, and is shown in column [3] of Table 14.

It should be stressed that this variable (volume loaded on vessels) includes refrigerated beef exports and hence, as introduced in the estimation, it is not strictly an exogenous variable. This implies that some estimates, in particular the estimated coefficients of the actual-planned export equation, may in fact be biased. More depurated information on total exports of beef may permit to disperse of this equation, and so lead to obtain more reliable estimates of the structure.

Data on Credit Conditions [X_{12}]

The variable used as proxy for credit conditions available to cattle farmers is the "net balance at the end of the year of credits granted to cattle farmers". This series was constructed in the following way: from 1952 up to date the information is taken as published by the Central Bank

[18/] U.N., "Statistical Yearbook", several issues. This organization also publishes information on "vessels entered" (net registered tons) and on "volume unloaded" in the same publication. While this latter is more related to import capacity, the former (net registered tons of vessels entered) may be considered an alternative proxy for shipment capacity (i.e., availability of shipping space).

Table 14. Price of Beef in England [X_7], Index of Real Income of Importing Countries [X_8], Tons of Vessels Loaded [X_9], and Net Balance of Credit Granted to Cattle Farmers [X_{12}], Period 1935-1966

Year	[1] Wholesale Price of Beef in England (dollars of 1960 per ton)[1/]	[2] Index Real Income of Importing Countries (1955 = 1000)[1/]	[3] Tons of Vessels Loaded (1000 metric tons)[2/]	[4] Net Balance of Credit Granted to Cattle Farmers (10 million pesos of 1960)[3/]
1935	941.42	699	16240	895.8
1936	963.71	714	14619	773.0
1937	1010.10	733	18235	804.2
1938	1029.65	747	9119	677.7
1939	983.95	766	12875	923.1
1940	938.09	809	9467	859.7
1941	892.77	852	6241	892.8
1942	908.35	899	5321	956.8
1943	894.88	895	5322	1018.3
1944	897.06	901	6147	1050.1
1945	890.44	872	6426	760.0
1946	905.52	820	8199	854.7
1947	1007.46	843	9306	1006.3
1948	1035.08	867	8759	1113.3
1949	962.13	890	5870	1402.3
1950	721.46	900	7381	1592.9
1951	704.88	832	5691	1270.2
1952	725.03	905	2977	1043.6
1953	735.36	941	7232	1361.8
1954	755.43	984	9652	1678.6
1955	825.34	1000	6871	1554.2
1956	730.49	1054	7214	1353.0
1957	777.44	1110	7693	1145.9
1958	769.15	1120	8477	1159.2
1959	764.56	1144	8872	785.9
1960	718.00	1264	9252	891.1
1961	722.16	1345	7127	1018.1
1962	706.99	1415	11719	662.5
1963	694.01	1484	10282	543.1
1964	711.14	1588	13252	957.7
1965	698.12	1655	15217	1038.6
1966	689.21	1718	15312	918.5

1/ Computed as indicated in the text.

2/ Source: U.N., "Statistical Yearbook", several issues.

3/ Source: (1935-1951) Banco Nacion Argentino y Banco Prov. Buenos Aires, Memorias Anuales and Internal statistics. (1952) D.N.E.C., Anuario Estadistico 1957". (1953-1965) B.C.R.A., "Boletin Estadistico", several issues.

of the Argentine Republic;[19] for the period 1935-1951, the figures correspond to net balance at the end of the year of credits granted by the two main institutions of agricultural credit: Banco Nación Argentino (BNA) and Banco Provincia de Buenos Aires.[20] These two institutions shared 96% of the total agricultural credit during the period 1952-1955. Since 1955, their relative importance started to decline. The procedure used in this study to couple both series consisted essentially in extrapolating by trend the share of banks other than the two mentioned above. The extrapolation yielded a practically constant 4% share for these institutions. The resulting series was deflated by the C.L.I. (Jan. 1960 - 100) and is shown in column [4] of Table 14.

Data on Prices of Grains [X_{13}]

The index of prices of grains used in this study is an annual price index of traditional crops in the Pampas computed by Reca.[21] This index includes prices (deflated by the C.L.I.) of four traditional crops weighted as follows: wheat .49, corn .33, flax .13 and oats .05. This series is presented in column [1] of Table 15.

Data on Rainfall [X_{11} and X_{14}]

In the economic model, "pasture conditions" was specified as an explanatory variable of the volume of slaughter. The variable used in

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[19] B.C.R.A., "Boletín Estadístico", several issues. The information for the year 1952 was obtained from D.N.E.C., "Anuario Estadistico 1957".

[20] Source: Annual Reports (Memorias Anuales) and internal statistics of both banks.

[21] Reca, op. cit., pp. 124-125.

the statistical model as a proxy for pasture conditions is a rainfall index introduced as a dummy variable to represent drought years (ones whenever the rainfall index falls below 85 in either the cattle breeding subregion or the rest of the Pampas, where normal year = 100; zeroes elsewhere) lagged one year. The variable is laged one year because, as Reca puts it:

> "The effects of abnormal weather (i.e., drought) are not felt immediately: the decrease in the yields of pasture takes place gradually. The recovery of the grazing lands after a drought is also progressive. Therefore it seems appropriate to include this variable lagged one year."[22/]

The rainfall indexes used in this study correspond to the Pampean Region and are those computed by Reca.[23/] Reca divides the Pampas into two zones:

> "...one is exclusively a cattle breeding zone (The Salado River Basin); it includes about 20 per cent of the total area of the Pampas and there cattle are raised almost exclusively on native pasture. The other zone is the rest of the Pampas. ...The rationale for this procedure (the use of a dummy variable) is the following: a drought affecting either the breeding region or the rest of the Pampas does not leave any room for moving cattle away from the drought stricken area, and thus acts as a shifter on the desired size of the herd."[24/]

The rainfall index for subregion "a" (five Pampa Provinces except cattle breeding area) and for subregion "b" (cattle breeding area) are presented in columns [2] and [3] of Table 15 respectively.

[22/] Reca, op. cit., p. 60.

[23/] Reca, op. cit., pp. 144-145.

[24/] Reca, op. cit., p. 60; second paragraph between parenthesis is mine.

Table 15. Index of Price of Grains [X_{13}] and Rainfall Indexes for the Pampean Region [X_{11} and X_{14}], for the Period 1934-1966

	[1]	[2]	[3]
		Rainfall Indexes	
Year	Price of Grains	Five Pampa Provinces Except CBA[2/]	Cattle Breeding Area [CBA][3/]
	(1935-1939 = 1000)[1/]		
1934	868	109.7	104.5
1935	847	91.0	85.7
1936	1014	118.6	105.7
1937	1242	71.3	67.6
1938	1022	93.6	109.3
1939	874	114.9	110.5
1940	749	129.6	121.3
1941	615	103.0	110.5
1942	613	93.2	94.9
1943	706	111.1	98.2
1944	757	101.3	90.8
1945	869	88.9	110.1
1946	1121	118.9	149.2
1947	1032	111.2	88.9
1948	1068	99.5	88.7
1949	898	92.9	112.5
1950	743	95.5	91.2
1951	750	87.8	107.6
1952	700	111.2	87.9
1953	855	111.6	104.6
1954	831	99.6	91.1
1955	777	104.1	95.4
1956	999	116.6	82.9
1957	987	97.5	77.9
1958	952	102.2	140.7
1959	1054	119.5	122.6
1960	1004	79.5	89.4
1961	1114	95.9	96.2
1962	1154	72.4	72.3
1963	1253	98.9	134.9
1964	1066	96.6	102.3
1965	904	81.7	83.7
1966	865	113.0	109.5

1/ Source: Reca, op. cit., pp. 124-125.

2/ Simple average. Source: Reca, op. cit. pp. 144-145.

3/ Source: Reca, op. cit., pp. 144-145.

APPENDIX B

ORDINARY LEAST SQUARES ESTIMATES

APPENDIX B
ORDINARY LEAST SQUARES ESTIMATES

In this section, the estimates obtained by applying ordinary least squares (OLS) procedure to what has been called "the structural model" are presented for comparison purposes. Again, the figures in parenthesis below the estimated coefficients are the estimates of their respective standard errors. A double asterisk indicates that the respective coefficient is more than twice as large as its standard error, and a single asterisk indicates that it is larger than its standard error. The Durbin-Watson statistic is represented by the letter "d". A plus sign (+) attached to the computed d-value indicates the presence of positive serial correlation; the letter (i) indicates inconclusive test and the letter (a) indicates that the hypothesis of non-serially correlated disturbances is not rejected at the .05 level of significance. The coefficient of multiple correlation is symbolized by R^2.

(B-1) Per-capita retail domestic demand (OLS):

$$Y_1 = 9779.49 - \underset{(.155)^{**}}{1.428}\, Y_2 + \underset{(.027)^{*}}{.039}\, X_1 + \underset{(.245)^{*}}{.338}\, X_2 + \hat{u}_1$$

$$R^2 = .84$$

$$d = .777^{(+)}$$

(B-2) Marketing group's behavior relation (OLS):

$$Y_2 = 1985.87 - \underset{(.159)^{*}}{.239}\, Y_3 + \underset{(.093)^{**}}{.959}\, Y_4 - \underset{(.063)^{*}}{.084}\, X_4 - \underset{(.104)^{**}}{.213}\, X_5 - \underset{(.096)^{**}}{.351}\, X_6 + \hat{u}_2$$

$$R^2 = .90 \quad d = .924^{(+)}$$

(B-3) Foreign demand for Argentine beef (OLS):

$$Y_5 = -2354.12 - .752\ Y_6 + .723\ X_7 + .266\ X_8 + u_3$$
$$(.227)^{**} \quad (.170)^{**} \quad (.065)^{**} \quad R^2 = .54$$
$$d = 1.270^{(i)}$$

(B-4) Actual-planned export relation (OLS):

$$Y_5 = -996.99 + .596\ Y_7 + .107\ X_9 + \hat{u}_4$$
$$(.052)^{**} \quad (.021)^{**} \quad R^2 = .88$$
$$d = 1.579^{(a)}$$

(B-5) Export packers group's behavior relation (OLS):

$$Y_8 = -536.42 + 1.178\ Y_4 + .028\ Y_7 + .055\ X_4 + .104\ X_5 - .655\ X_6 + \hat{u}_5$$
$$(.128)^{**} \quad (.053) \quad (.075) \quad (.141) \quad (.179)^{**}$$
$$R^2 = .86$$
$$d = 1.192^{(i)}$$

(B-6) Slaughter supply of steers and yearly steers (OLS):

$$Y_9 = -277.32 + .129\ Y_4 + .122\ X_{10} + .273\ X_{11} - .368\ X_{16} + \hat{u}_6$$
$$(.145) \quad (.011)^{**} \quad (.126)^{**} \quad (.148)^{**} \quad R^2 = .87$$
$$d = 1.752^{(a)}$$

(B-7) Slaughter supply of cows, heifers, bulls and calves (OLS);

$$Y_{10} = -118.54 - .831\ Y_4 + .193\ X_{10} + .406\ X_{11} - .734\ X_{16}$$
$$(.318)^{**} \quad (.027)^{**} \quad (.276)^{*} \quad (.316)^{**}$$
$$- 1.432\ X_{12} + .156\ X_{13} + \hat{u}_7$$
$$(.497)^{**} \quad (.702) \quad R^2 = .78$$
$$d = 1.001^{(+)}$$

(B-8) Average weight equation (OLS):

$$Y_{11} = 2111.41 + .055\ Y_9 - .062\ Y_{10} - .032\ X_2 - .033\ X_{14} + \hat{u}_8$$

$$(.020)^{**} \quad (.008)^{**} \quad (.013)^{**} \quad (.013)^{**} \qquad R^2 = .79$$

$$d = 1.345^{(i)}$$

APPENDIX C

ESTIMATES OF THE STRUCTURE BASED ON 21 OBSERVATIONS

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ESTIMATES OF THE STRUCTURE BASED ON 21 OBSERVATIONS

The estimates obtained by applying two stage least square (2SLS) procedure, on the basis of a sub-sample period, are presented here for comparison purposes. As it is explained in Chapter IV, the years 1947 to 1957 were excluded from the sample; hence, the sub-sample is formed by the data for the years 1935 through 1946 and 1958 through 1966. The years excluded from the sample correspond to the years of interventionism in the beef-cattle industry. A slight modification was made to account for the possibility of change in structure from pre-to post-intervention period. A dummy variable X_{17} (zeroes for 1935-46 and ones for 1958-66) replaced the dummy variable X_6 in the marketing group's and export-packers' behavior equations, and was introduced as a shifter of the actual-planned export relation. Symbols have the same meaning as in Chapter IV and Appendix C.

(C-1) Per-capita retail demand (2SLS):

$$Y_1 = 8654.12 - \underset{(.282)^{**}}{1.472}\, Y_2 + \underset{(.052)^{*}}{.097}\, X_1 + \underset{(.425)}{.089}\, X_2 + \hat{v}_1 \qquad R^2 = .67$$

$$d = 1.346^{(i)}$$

(C-2) Marketing group's behavior relation (2SLS):

$$Y_2 = 3675.08 - 1.364\,Y_3 + .489\,Y_4 - .121\,X_4 - .063\,X_5 + 1.131\,X_{17} + \hat{v}_2$$

$$(.574)^{**} \quad (.192)^{**} \quad (.082)^{*} \quad (.113) \quad (.481)^{**}$$

$$R^2 = .91$$

$$d = 1.519^{(i)}$$

(C-3) Foreign demand for Argentine beef (2SLS):

$$Y_5 = -9598.48 - .734\,Y_6 + 1.307\,X_7 + .489\,X_8 + \hat{v}_3$$

$$(.327)^{**} \quad (.397)^{**} \quad (.143)^{**} \quad R^2 = .50$$

$$d = 1.218^{(i)}$$

(C-4) Actual-planned export relation (2SLS):

$$Y_5 = -865.36 + .575\,Y_7 + .096\,X_9 + .373\,X_{17} + \hat{v}_4$$

$$(.089)^{**} \quad (.024)^{**} \quad (.182)^{**} \quad R^2 = .78$$

$$d = 1.570^{(i)}$$

(C-5) Export packers group's behavior relation (2SLS):

$$Y_8 = 161.04 + .922\,Y_4 - .025\,Y_7 - .028\,X_4 + .026\,X_5 + .456\,X_{17} + \hat{v}_5$$

$$(.095)^{**} \quad (.038) \quad (.064) \quad (.090) \quad (.124)^{**}$$

$$R^2 = .96$$

$$d = 1.710^{(i)}$$

(C-6) Slaughter supply of steers and yearly steers (2SLS):

$$Y_9 = -183.22 + .122\,Y_4 + .124\,X_{10} + .233\,X_{11} - .445\,X_{16} + \hat{v}_6$$

$$(.184) \quad (.016)^{**} \quad (.168)^{*} \quad (.175)^{**} \quad R^2 = .89$$

$$d = 2.285^{(a)}$$

(C-7) Slaughter supply of cows, heifers, bulls and calves (2SLS):

$$Y_{10} = -750.39 - .736\ Y_4 + .220\ X_{10} + .432\ X_{11} - .971\ X_{16}$$
$$(.298)^{**} \quad (.029)^{**} \quad (.272)^{*} \quad (.294)^{**}$$
$$- .706\ X_{12} + .838\ X_{13} + \hat{v}_7$$
$$(.783) \quad (.745)^{*} \qquad R^2 = .87$$
$$d = 1.222^{(i)}$$

(C-8) Average weight equation (2SLS):

$$Y_{11} = 2265.18 + .046\ Y_9 - .067\ Y_{10} - .034\ X_2 - .023\ X_{14} + \hat{v}_8$$
$$(.037)^{*} \quad (.015)^{**} \quad (.018)^{*} \quad (.017)^{*} \quad R^2 = .80$$
$$d = 1.498^{(i)}$$

APPENDIX D

AN ALTERNATIVE SET OF ESTIMATES

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AN ALTERNATIVE SET OF ESTIMATES

An alternative set of estimates corresponding to the parameters of the "export related" equations of the model: foreign demand for Argentine beef (4-3), actual-planned export relation (4-4), and export packers' behavior relation (4-5), is presented in this appendix for comparison purposes. These different estimates are obtained when different data is used for the endogenous variables Y_5, Y_6 and Y_8. The data on these variables used to obtain the estimate of the structure presented in Chapter IV were related to exports of refrigerated beef; the data used to obtain the estimates presented below are related to total exports of beef. The new variables are:

Y'_{5t} = total quantity exported of beef in 100 tons.

Y'_{6t} = average price of Argentine exports of beef in U.S. dollars of 1960 per 10,000 kgs. F.O.B. Buenos Aires, computed as value of beef exports divided by volume.

Y'_{8t} = net price received for total exports of beef in pesos of 1960 per 100 kgs.

Three sets of estimates are presented for each equation. The first, (a), corresponds to 2SLS estimates obtained on the basis of the complete sample (1935-1966). The second, (b), corresponds to OLS estimates obtained also on the basis of the complete sample period. The third, (c), corresponds to 2SLS estimates obtained on the basis of the sub-sample

period (1935-46 and 1958-66) as defined in Appendix C.

(D-1) Foreign demand for Argentine beef (total beef):

(a) Period 1935-66 (2SLS)

$$Y_5' = 7035.71 - .783\ Y_6' + .151\ X_7 + .044\ X_8 + \hat{U}_3'$$
$$(.179)^{**} \quad (.252) \quad (.087) \quad R^2 = .52$$
$$d = 1.590^{(i)}$$

(b) Period 1935-66 (OLS)

$$Y_5' = 6017.30 - .700\ Y_6' + .213\ X_7 + .059\ X_8 + \hat{u}_3'$$
$$(.138)^{**} \quad (.225) \quad (.079) \quad R^2 = .58$$
$$d = 1.551^{(i)}$$

(c) Period 1935-46 and 1958-66 (2SLS)

$$Y_5' = -814.39 - 1.595\ Y_6' + .983\ X_7 + .413\ X_8 + \hat{v}_3'$$
$$(.547)^{**} \quad (.527)^{*} \quad (.197)^{**} \quad R^2 = .41$$
$$d = 2.050^{(a)}$$

(D-2) Actual-planned export relation (total beef):

(a) Period 1935-66 (2SLS)

$$Y_5' = 219.56 + .972\ Y_7 + .087\ X_9 + \hat{U}_4'$$
$$(.106)^{**} \quad (.357) \quad R^2 = .76$$
$$d = 2.160^{(a)}$$

(b) Period 1935-66 (OLS)

$$Y_5' = 566.19 + .888\ Y_7 + .189\ X_9 + \hat{u}_4'$$
$$(.055)^{**} \quad (.222) \quad R^2 = .91$$
$$d = 2.177^{(a)}$$

(c) Period 1935-46 and 1958-66 (2SLS)

$$Y_5' = 27.75 + .976\ Y_7 + .139\ X_9 + .169\ X_{17} + \hat{v}_4'$$
$$(.103)^{**} \quad (.277) \quad (.221) \qquad R^2 = .84$$
$$d = 2.319^{(a)}$$

(D-3) Export packers group's behavior relation (total beef):

(a) Period 1935-66 (2SLS)

$$Y_8' = 96.14 + 1.175\ Y_4 - .026\ Y_7 - .059\ X_4$$
$$(.136)^{**} \quad (.087) \quad (.082)$$
$$+ .044\ X_5 - .295\ X_6 + \hat{U}_5'$$
$$(.148) \quad (.244)^{*} \quad R^2 = .825$$
$$d = 1.639^{(i)}$$

(b) Period 1935-66 (OLS)

$$Y_8' = 249.19 + 1.144\ Y_4 - .049\ Y_7 - .052\ X_4$$
$$(.117)^{**} \quad (.049) \quad (.069)$$
$$+ .054\ X_5 - .357\ X_6 + \hat{u}_5'$$
$$(.128) \quad (.164)^{**} \quad R^2 = .86$$
$$d = 1.430^{(i)}$$

(c) Period 1935-46 and 1958-66 (2SLS)

$$Y_8' = 561.46 + .777\ Y_4 - .032\ Y_7 + .078\ X_4$$
$$(.112)^{**} \quad (.042) \quad (.079)$$
$$- .078\ X_5 + .726\ X_{17} + \hat{v}_5'$$
$$(.109) \quad (.149)^{**} \quad R^2 = .95$$
$$d = 1.554^{(i)}$$

APPENDIX E

AN EXAMPLE OF THE MODEL IN POLICY FRAMEWORK

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AN EXAMPLE OF THE MODEL IN POLICY FRAMEWORK

Suppose that the policy problem is stated as that of achieving a certain level of exports Y_5^t and also maintaining the retail price at a given level, say Y_2^t. The question is, if the values of all other predetermined variables are predictable, which are the values to be assumed by the instrument variables, say X_{12}^i and X_{15}^i, in order to achieve targets Y_2^t and Y_5^t.

The procedure consists of reducing the structural system to a more manageable system,[1/] and rearranging the resulting equations such that the instrument variables [X_{12}^i and X_{15}^i in this case] and the remaining non-target endogenous variables are expressed as a function of the target variables [Y_2^t and Y_5^t in this example]. For instance, the system of eleven equations in eleven structural endogenous variables presented in Chapter IV may be reduced to a more compact system of five equations [equations (E-1) through (E-5)] in five endogenous variables. Such system should include all target and instrument variables. The steps to be followed in this case are:

[1/] See: Tinbergen J., On the Theory of Economic Policy. Amsterdam: North Holland Publishing Co., 1955.
_____, Economic Policy, Principles and Design, Amsterdam: North Holland Publishing Co., 1956.
Fox, Karl A., Sengupta, J. K. and E. Thorbecke, The Theory of Quantitative Economic Policy with Applications to Economic Growth and Stabilization, Rand McNally & Co., Chicago 1966.

(a) solve (4-1) and (3-9) to obtain the "aggregate domestic retail demand" (E-1), considering Pop (1969) : X_{3t} = 23.7 million inhabitants. The variable Y_1 is eliminated.

(b) solve (4-3) and (3-10) to obtain the "foreign demand for Argentine beef" expressed as function of the price in domestic currency Y_8 and exchange rate X_{15}. The variable Y_6 is thus eliminated. Solve the resulting equation and (4-5) to obtain (E-3); the variable Y_8 drops out.

(c) substitute (4-6), (4-7) and (4-8) in (3-11) to obtain (E-5); the variables Y_9, Y_{10} and Y_{11} are then removed from the system.

(d) equations (E-2) and (E-4) are equations (4-2) and (4-4) respectively.

The resulting system is

(E-1)
$$Y_3 = (-.347)\, Y_2^t + [2355.39 + .0085\, X_1 + .089\, X_2]$$

(E-2)
$$.243\, Y_3 - .962\, Y_4 = -\, Y_2^t + [1981.40 - .084\, X_4 - .212\, X_5 - .349\, X_6]$$

(E-3)
$$1.947\, Y_4 - 1.045\, Y_7 - .6862\, X_{15}^i = -\, Y_5^t + [-4702.99 + .1319\, X_4 - .2304\, Y_5 + 1.310\, X_6 + .713\, X_7 + .2657\, X_8]$$

(E-4)
$$-\, .657\, Y_7 = -\, Y_5^t + [-1248.96 + .099\, X_9]$$

(E-5)
$$Y_3 - .0093\, Y_4 + .1\, Y_7 + .2314\, X_{12}^i = [-74.88 - .02545\, X_2 + .0626\, X_{10} + .17985\, X_{11} + .0344\, X_{13} - .02727\, X_{14} - .3044\, X_{16}]$$

which in matrix notation can be written as

$$B \cdot Z' = \Gamma Y' + M'$$

hence $\quad Z' = B^{-1}\,\Gamma Y' + B^{-1}M'$

where B is a five by five matrix of the coefficients of the instrument and non-target endogenous variables, Z' is a column vector of the instrument and non-target endogenous variables, Γ is a five by two matrix of the coefficients of target variables, Y' is a column vector of the target variables, and M' is a column vector of data.

$$\begin{bmatrix} 1 & & & & \\ .243 & -.962 & & & \\ & 1.947 & -.6862 & -1.045 & \\ & & & -.657 & \\ 1 & -.0093 & & .1 & .2314 \end{bmatrix} \cdot \begin{bmatrix} Y_3 \\ Y_4 \\ X^i_{15} \\ Y_7 \\ X^i_{12} \end{bmatrix} = \begin{bmatrix} -.347 & 0 \\ -1 & 0 \\ 0 & -1 \\ 0 & -1 \\ 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} Y^t_2 \\ Y^t_5 \end{bmatrix} + \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \\ \mu_5 \end{bmatrix}$$

The det B is evaluated by expansion in terms of elements of the 4th row of B

$$\det B = (-.657)\ (-1)^{4+4} \begin{vmatrix} 1 & 0 & 0 & 0 \\ .243 & -.962 & 0 & 0 \\ 0 & 1.947 & -.6862 & 0 \\ 1 & -.0093 & 0 & .2314 \end{vmatrix}$$

$\det B = -.10036 \neq 0$

Thus, the system may be solved for the values of Y_3, Y_4, X^i_{15}, Y_7 and X^i_{12}. For example, if the target values and the predicted values (for 1969) of the non-instrument predetermined variables are as

Table 16. Targets and Predicted Values of Non-instrument Predetermined Variables for the Year 1969.*

Variables				Targets and Predicted Values	Values in 1966
Targets:	Q^{xd}	:	Y_5^t	4100	(3981)
"	P^r	:	Y_2^t	4000	(3449)
Data	Y^{pc}	:	X_1	44000	(43788)
"	Z_t	:	X_2	3500	(3200)
"	P^{bp}	:	X_4	2200	(2197)
"	W	:	X_5	3100	(3068)
"			X_6	0	(0)
"	P^{ob}	:	X_7	770	(689)
"	Y^{oc}	:	X_8	1750	(1718)
"	Tn	:	X_9	1550	(1531)
"	I_t	:	X_{10}	51500	(53977)
"	X_{t-1}	:	X_{11}	1000	(0)
"	P^g_{t-1}	:	X_{13}	930	(904)
"	X_t	:	X_{14}	0	(0)
"	P^f_{t-1}	:	X_{16}	2500	(2340)
Instruments:	CC^b	:	X^i_{12}	?	(918)
"	Exr	:	X^i_{15}	?	(6824)

*These values are completely arbitrary and constitute just an example.

specified in Table 16. The data vector is

$$M = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \\ \mu_5 \end{bmatrix} = \begin{bmatrix} 3040.89 \\ 1139.40 \\ -4113.07 \\ -1095.51 \\ 2510.45 \end{bmatrix}$$

and the solution is

$$Z' = \begin{bmatrix} Y_3 \\ Y_4 \\ X^i_{15} \\ Y_7 \\ X^i_{12} \end{bmatrix} = \begin{bmatrix} 1652.89 \\ 3391.06 \\ 9779.59 \\ 7755.70 \\ 491.00 \end{bmatrix}$$