LIVESTOCK INDUSTRY IN CANADA
AN INPUT-OUTPUT ANALYSIS
1941-1975

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by

Leon Chin-Shin Lin

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ABSTRACT

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In the light of the past changes and the changes which are very likely to occur in the next 10 years, in both population and per capita income, this study is an attempt to analyze the structural adjustments in agriculture in general, and in the livestock industry in particular, taking into consideration the interrelationships between relevant sectors of the economy. Emphasis has focused on beef and pork production in Manitoba and in the Prairie region.

By 1975 a 60 percent increase in consumption of red meats over that in 1960 has been projected. Shefrin and Menzies predicted that per capita consumption of red meats would be 163 lbs. in 1975. This expansion in meat consumption has had very far reaching implications for both the agricultural producers and the meat slaughtering and processing industry. Even more significant changes will occur within the agricultural industry over the next 10 years if the projected increase in beef and pork consumption is realized. The important question for the livestock producers and the processing industry is where this expected increase in consumption will be produced and processed. In line with

this, another important problem presents itself, viz., how the primary sector of the economy will be affected. Many studies on these problems have been undertaken and some relevant hypotheses made accordingly. But none of these studies are based on an inductive analysis, taking general equilibrium of the whole economy into consideration. The main objective of this study is thus to fill this gap and to put those relevant hypotheses to further empirical test.

It is hoped that this study will provide some worthwhile information which can be used by governments or other planning agencies in their policy-making; by business firms which market and/or process livestock and livestock products; and by individual farmers who are the core of agricultural production. Although the major problems tackled in this study may have little direct relevance to the operation of an individual farm, the study nevertheless, would provide some indirect aids to individual farmers, such as information on cost structure in livestock production, movements of livestock between provinces, and livestock production trends.

The main analytical tool used is Professor Leontief's open input-output model. Input-output analysis is aimed at a study of interrelationships between various parts of an economy. The basic model set up for the livestock industry in Canada in this study includes eight intermediate sectors, the unallocated sector, and four final demand sectors. All sectors are measured at the national level. In addition to

the input-output approach other methods of analysis, such as time series analysis, are also used when applicable.

The following is a condensed summary of the findings of the study:

1. It was found that greater technological changes occurred in livestock production between the period 1941-1951 than during the period 1951-1961. While there were technical changes in primary agriculture in the period 1941-1951, very little change occurred during the period 1951-1961.

2. About 95 percent of beef and pork has been produced in the Central and the Prairie region since 1940. From 1950 there has been a tendency for beef and pork production in the Central region to become less and less important as compared to the production in the Prairie region.

3. It is estimated that total beef production in Canada by 1975 will increase by approximately 53 percent over that produced in 1960. Of the beef cattle increase in Canada, it is expected that about 83 percent of this increase will originate in the Prairie Provinces. In 1975 there will be a 61 percent increase in beef production in Manitoba over that of 1960.

4. It is estimated that hog production in Canada will have to increase by approximately 73 percent between the years 1960 and 1975 if the anticipated demand for pork by 1975 is to be satisfied. Of the increase, approximately 59 percent will be produced in the Prairie Provinces. Manitoba hog producers will probably more than double their production between

1960 and 1975.

5. The shipments of live animals from the Prairie Provinces to British Columbia and Eastern Canada are unlikely to increase in proportion to total shipments of the same provinces by 1975. But it is conceivable that there would be a large increase in output from the meat processing industry in the Prairie Provinces, and that an increasing portion of the output of this industry would flow to British Columbia, Eastern Canada and the United States.

6. In 1975 the meat processing industry in Canada will require a 70 percent increase in employment over that of 1961. For Manitoba plants it is estimated that approximately 500 - 600 additional workers will be required by 1975. These employment estimates were made under the assumption that there will be little or no technological changes in the meat processing industry by that time.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

This study can be viewed as a continuation or part of a more comprehensive and deductive-type one -- "Development of the Livestock Industry in Canada by 1975 and Implications for the Meat Processing Industry in Manitoba", conducted by the Department of Agricultural Economics, University of Manitoba in 1962. It is hoped that by employing Professor Leontief's input-output technique the present study would be able to provide: (1) A more penetrating analysis of the possible development of the livestock industry and the meat processing industry in Canada in general, and in the Prairie Provinces and Manitoba in particular; and (2) additional information on the situation of the livestock industry and other related industries, such as inter-sector flows of relevant goods and services, general input functions, interdependence between sectors, and aggregate technical changes during the past few decades.

The analysis of the problem. "No meat, no meal" may be merely a slogan or motto some decades ago, but it is no longer applicable today. The fact, as shown in Table I, is that per capita consumption of red meats in this country has continuously increased from 131.5 lbs. during 1950 - 1954 to

TABLE I

PER CAPITA PERSONAL DISPOSABLE INCOME AND PER CAPITA CONSUMPTION OF RED MEATS AND CEREALS IN CANADA, 1950 - 1965

Year	Per Capita Personal Disposible Income (1)	Per Capita Consumption (2)	
		Red Meats	Cereals
	$	Lbs.	Lbs.
1950-54	1,068.6	131.5	168.0
1955-59	1,281.2	141.8	159.8
1960-64	1,517.6	143.1	151.7
1965	1,788.0	146.3	159.3

Source: (1) DBS, 11-502, Canadian Statistical Review, Historical Summary, 1963 ed. and DBS 13-201 National Accounts, Income and Expenditure, 1965.

(2) DBS, Handbook of Agricultural Statistics, Part IV, Food Consumption in Canada, 1926-1955 and DBS 32-226, Apparent Per Capita Disappearance of Food in Canada, 1958-1965.

143.1 lbs. during 1960 - 1964; the amount for 1965 was 146.3 lbs. Two major factors account for this phenomenon; population growth and the rise in level of disposable income per capita. From Figure 1 we can see how closely the population and the livestock production have expanded simultaneously since 1950. The correlation coefficient between the two is +0.96, almost equal to unity. It indicates that there existed a strong bond between them, and that livestock production in Canada was primarily aimed at meeting the domestic needs rather than increasing foreign exchange. In the meantime, per capita personal disposable income has increased from $925 in 1950 to $1,788 in 1965. This nearly doubling of income has caused changes in the consumer's food basket. While there has been a steady increase in consumption of red meats, the per capita domestic disappearance of cereals decreased (also see Table I).

Foreign trade of livestock and livestock products has been quite variable over the last 15 years. As shown in Table II, coefficients of variation for exports of beef, pork, and mutton and lamb are 67.59 percent, 26.70 percent and 158.63 percent, respectively; and for imports of these same products are 33.81 percent, 131.15 percent and 78.69 percent, respectively. The fluctuation in exports of mutton and lamb has been the greatest from year to year. The amounts of pork have been the most variable in terms of the imports

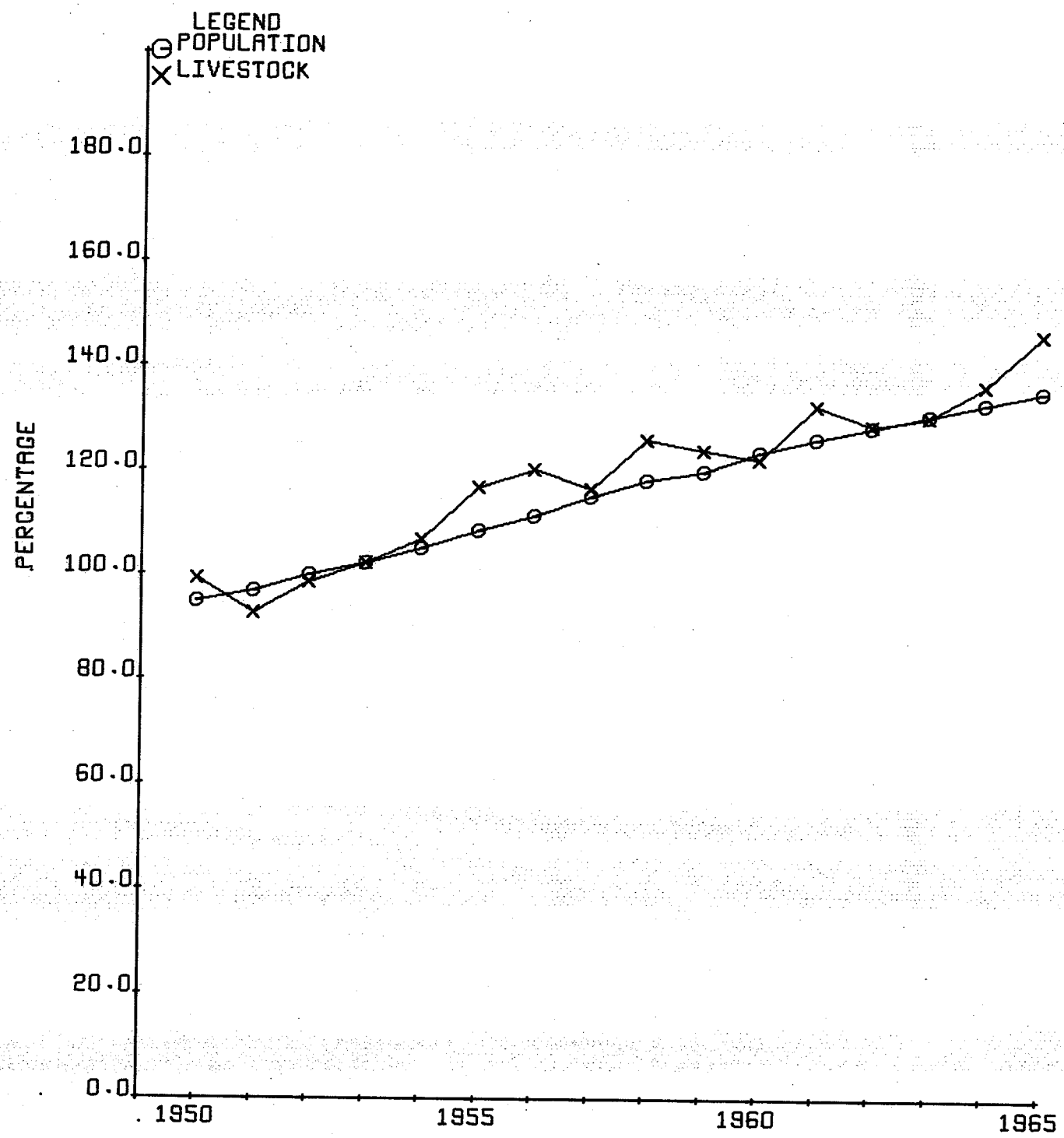

FIG. 1 CANADA POPULATION AND LIVESTOCK PRODUCTION 1950-1965 (1950-1954=100)

TABLE II

EXPORTS AND IMPORTS OF MEATS FROM AND INTO CANADA
1950 - 1965 (Thousand Pounds)

Year	Exports			Imports		
	Beef	Pork	Mutton & Lamb	Beef	Pork	Mutton & Lamb
1950	84,412	84,807	2,761	10,417	6,005	486
1951	93,485	29,314	2,737	23,382	22,629	3,499
1952	67,003	26,419	46	21,015	4,825	2,661
1953	26,194	69,574	52	20,313	436	4,745
1954	19,934	69,951	53	28,935	1,482	7,324
1955	9,858	73,275	273	30,936	116	10,829
1956	13,687	61,956	45	27,116	111	9,563
1957	48,351	40,303	472	36,470	1,346	11,032
1958	54,970	65,979	1,377	38,043	1,533	21,548
1959	23,960	69,166	749	49,425	1,212	20,119
1960	19,998	69,690	109	38,541	17,061	23,532
1961	31,239	57,120	173	41,680	40,653	33,436
1962	21,757	58,761	556	45,557	34,464	37,916
1963	19,920	63,194	679	49,512	88,487	48,063
1964	34,242	52,637	757	36,287	52,614	37,654
1965	82,705	54,922	370	27,464	36,605	30,990
Means	40,732	59,192	701	32,818	19,349	18,962
Standard deviations	27,530	15,804	1,112	11,097	25,376	14,921
C.V.(%)	67.59	26.70	158.63	33.81	131.15	78.69

Source: Trade of Canada. DBS 65-004 and 65-006.

of red meats. As to the future trend, it is expected that due to market limitations and, perhaps, even more important, the increase in domestic requirements, little or no expansion will be realized in the present level of Canada's exports of live animals and meats. Indeed it is more than possible that, in occasional years, Canada will be a net importer of beef. However, imports of livestock and livestock products have never amounted to a significant percentage of total production.[1]

By 1975, about a 60 percent increase in consumption of red meats over that in 1960 has been projected.[2] Menzies and Shefrin predicted that per capita consumption of red meats would be 163 lbs.[3] This expansion in meat consumption has had very far-reaching implications for the agricultural producers and the meat slaughtering and processing industry.

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[1]W. M. Drummond and W. Mackenzie, Progress and Prospects of Canadian Agriculture, Royal Commission on Canada's Economic Prospects, January, 1957, pp. 56-60; R. V. Anderson, The Future of Canada's Export Trade, RCOCEP, March, 1957, pp. 142-145.

[2]Department of Agricultural Economics, University of Manitoba, Development of the Livestock Industry, etc.,

[3]M. W. Menzies, and F. Shefrin, "Demand Outlook for Canadian Agriculture", in Resources for Tomorrow, July 1961, p. 23.

Even more significant changes will occur within the agricultural industry over the next 10 years if the projected increase in beef and pork consumption is realized.

The important question for the livestock producers and the processing industry is where this expected increase in consumption will be produced and processed. In line with this, another important problem presents itself, viz., how the primary sector of the economy will be affected. Many studies in these respects have been done and some relevant hypotheses made accordingly. But none of them are based on an inductive analysis, taking general equilibrium of the whole economy into consideration. The main objective of this study is thus to fill this gap and to put those hypotheses to further empirical test. In order to envisage the significant changes which are likely to occur within the agricultural industry and between agricultural and other sectors of the economy, some measurements of quantitative relationships would appear to be necessary.

Some specific objectives. This study was mainly designed to answer the important questions raised in the previous section. In addition, some specific objectives are as follows:

1. To describe the flows between sectors closely related to livestock production.

2. To determine some major components of the cost structure in livestock production.

3. To quantify the interdependence between sectors closely related to the livestock industry.

4. To test the significance and possibility of applying Professor Leontief's input-output analysis to a particular industry or economy such as livestock at a national level.

It is hoped that this study will provide some worthwhile information which can be used by governments or other planning agencies in their policy-making; by business firms market and/or process livestock and livestock products; and by individual farmers who are the core of agricultural production. Although the major problems tackled in this study may have little direct relevance to the operation of an individual farm, the study, nevertheless, would provide some indirect aids to individual farmers, such as information on cost structure in livestock production, movements of livestock between provinces, and livestock production trends.

Unfortunately, the original attempt in conducting a study on both regional and sectorial basis was thwarted by lack of necessary data and limited amount of time available for this research. However, special emphasis has been placed on Manitoba and the Prairie region within the national frame-

work of the study by drawing most of the implications from the study with respect to them.

Methodology. As stated in the very beginning of this chapter, the principal analytical tool to be employed in the following is Professor Leontief's open input-output model in accordance with the nature of the problems. Other methods of analysis such as regression analysis on time series data and time series analysis are also used when applicable.

This study was initiated in 1963. Consequently, 1961 was the most recent year with relatively adequate published data. Data for 1941 and 1951 census years were also collected and analyzed in order that intertemporal comparisons could be made. Most of the data was provided by Dominion Bureau of Statistics.

Organization of the thesis: In order that the input-output model used in this study can be better understood, a brief account of the basic logic involved is first given in the next chapter. A specific input-output model developed for livestock industry in Canada is then presented. This model is to be employed as an essential setting for the study throughout. On the basis of it, data were gathered, analyzed, projections made, and implications drawn. Chapter IV contains the empirical results and a short explanation about input-output tables for the 1961 model. Economic

implications of this model along with others were derived in Chapter V. Thus, through Chapter II and Chapter V, the descriptive part of the analysis was discussed. At the same time it laid the basis for further analysis to be conducted in Chapter VI. In Chapter VI projections on beef and pork production were made on the basis of the 1961 model with the aid of a simple regression analysis. Future movements of livestock and livestock products were dealt with in the light of the past trend. Finally, the effects of an increase in demand for red meats on the level of employment in meat processing industry were analyzed.

CHAPTER II

INPUT-OUTPUT FRAMEWORK

Historical background. The original idea of input-output models in economics can be traced back to the Tableau Economique of Quesnay, published in 1758. It had productive industry (agriculture), service industries, and a final demand sector presented in a form strongly suggestive of present day input-output models.[4] About one hundred and twenty years later, a formal analysis of the interdependence of economic units was presented by Walras of Lausanne University in his Elements d'Economie Politique Pure. The corresponding field of applied economics has developed only in the last few decades. Its origin is in the pioneering work of Professor Wassily W. Leontief, who first applied his input-output model to empirical studies of the American economy in 1931 and published his first results in 1936 and 1941. Since then, the input-output approach has developed greatly, and alternative models have been suggested.[5]

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[4]A. Philips, "The Tableau Economique as a Simple Leontief Model, "Quarterly Journal of Economics, LXIX, No. 1, (February, 1955), 137-44.

[5]Wassily W. Leontief, The Structure of American Economy, 1919-1939, Second Edition Enlarged, Oxford University Press, New York, 1951.

Leontief started his study with a "closed" model, in which all sectors are both producers and consumers. In other words, all sectors are assumed to be interdependent with functionally related inputs and outputs. If, on the other hand, some sectors are related to other sectors but are not functionally dependent upon them, the system is "open". Prior to World War II, input-output analysis dealt only with closed models, the objective being determination of the necessary production from each sector to meet the input requirements of all other sectors. Subsequently, emphasis has shifted to the open models which are more applicable in determining levels of sector outputs consistent with a specified final or consumer demand.

Most of input-output studies have been conducted at the national level, such as those in Canada, United States, Denmark, France, Japan, Germany, Austria, Great Britain, Isreal, Italy, the Netherlands, Norway and the USSR. Regional input-output models were developed by Isard, Moses, and Chenery.[6] Regional models define industries spatially as well as by type of product or service produced.

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[6] H. C. Carter and E. O. Heady, An Input-Output Analysis Emphasizing Regional and Commodity Sectors of Agriculture, Iowa Agr. Expt. Sta. Res. Bul. 469, 1959.

Schnittker and Heady[7] constructed a regional model of agriculture for 1949 in the United States which considered six regions subdivided into primary and secondary agriculture and six national industry sectors. Carter and Heady[8] expanded on Schnittker's work in constructing a regional and commodity model of agriculture for 1954 which considered ten agricultural regions, nine commodity sectors and three major categories of industries on a national basis. Examples of input-output studies on a particular region are Wright's[9] and Martin's[10]. Ram[11] of North Carolina even applied input-output analysis in a regional study of a small homogeneous agricultural area including eight counties.

Input-output research is still admittedly deficient in one important respect: It uses mainly static instead of dynamic models. Although the formal properties of dynamic models have in recent years been investigated, the lack of adequate information on the relationship between capital and output

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[7]J. A. Schnittker and E. O. Heady, Application of Input-output Analysis to a Regional Model Emphasizing Agriculture, Iowa Agr. Expt. Sta. Res. Bul. 454, 1958.

[8]Carter and Heady, loc. cit.

[9]R. W. Wright, The Alberta Economy -- An Input-Output Analysis, Dept. of Economics, University of Alberta, Calgary, 1962.

[10]W. E. Martin and H. O. Carter, A California Inter-Industry Analysis Emphasizing Agriculture, Part I: The Input-Output Models and Results, California Agr. Expt. Sta. Res. Report No. 250, February, 1962.

[11]P. Ram, An Input-Output Analysis of A Small Homogeneous Agricultural Area, North Carolina Agr. Exp. Sta. Paper No. 948 of the Journal Series, August, 1958 (Mimeo).

still prevents empirical application.

The basic model. Input-output or interindustry economics can be regarded as a vast collection of data describing our economic system, and/or as an analytical technique for explaining and predicting the behaviour of our economic system. The essential part of empirical input-output work is the input-output table. Two piers on which the analytical phase of input-output work has been built are: (1) a set of accounting equations, one for each industry (i.e., transaction matrix). The equation for any industry says that its total output is equal to the sum of all the entries in that industry's row in the input-output table; (2) another set of equations, at least one for each industry. The first group of these equations shows the relationships between the output of the first industry and the inputs it must get from other industries in order to produce its own output, the others do the same for the second and all other industries (i.e., input-output coefficient matrix). Having these two, we are able to derive the third set of equations by which the measurement of interdependence between industries is made possible. The following is an algebraic presentation of a basic open input-output model:

Let X_i represent the total physical output of industry i, i = 1, 2, ..., m; each of these magnitudes being expressed in terms of appropriate physical units, such as tons, yards,

barrels, or "quantity purchasable for $1,000,000 at given prices". To facilitate later analysis and to aggregate into a workable number of sectors, money units are generally employed. And x_{ij} will indicate the amount of product of industry i used in industry j, i,j = 1, 2, ..., m, with or without i and j being equal. In case i = j is adopted we are dealing with gross output of each industry, otherwise, net output. Analysis using gross output can provide us more information as to internal transactions of each industry. Availability of data and the objective of the study will dictate a choice between the two. If x_{in} stands for the amount of output of industry i which is used for direct household consumption and thus is entered into the final bill of goods(i.e., final demand), then, by definition, the input-output table can be expressed through the following self-explanatory system of equations:

$$
\begin{aligned}
& X_1 - x_{11} - x_{12} - \cdots - x_{1m} = x_{1n} \\
- & \; x_{21} + X_2 - x_{22} - \cdots - x_{2m} = x_{2n} \\
& \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
& \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
& \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
- & \; x_{m1} - x_{m2} - x_{m3} - \cdots + X_m = x_{mn}
\end{aligned}
\qquad \text{(II - 1)}
$$

or,

$$X_i - \sum_j x_{ij} = x_{in}$$

where, i,j = 1,2,...., m.

By the same token, total labor force denoted by X_o may be treated as a gross output, although the following

equation will not enter the final solution of the model:

$$X_o - x_{o1} - x_{o2} - \dots - x_{om} = x_{on}$$

From this transaction matrix, the relation between the total output of any particular industry, say X_1, and the amounts, x_{11}, x_{21}, ... x_{m1}, of the products of its own and other industries absorbed in the process of its production can be derived. Thus, we have the second matrix, called input-output or technical coefficient matrix, and its corresponding system of equations:

$$\begin{aligned}
&x_{11} = a_{11}X_1,\ x_{21} = a_{21}X_1,\ \dots\ x_{m1} = a_{m1}X_1;\\
&x_{12} = a_{12}X_2,\ x_{22} = a_{22}X_2,\ \dots\ x_{m2} = a_{m2}X_2;\\
&\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\\
&\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\\
&\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\\
&x_{1m} = a_{1m}X_m,\ x_{2m} = a_{2m}X_m,\ \dots\ x_{mm} = a_{mm}X_m
\end{aligned} \qquad \text{(II - 2)}$$

In respect to labor function of each industry, similarly, a set of equations can be obtained:

$$x_{o1} = a_{o1}X_1;\ x_{o2} = a_{o2}X_2;\ \dots;\ x_{om} = a_{om}X_m$$

Substituting system (II - 2) into system (II - 1), we obtain,

$$\begin{aligned}
&X_1 - a_{11}X_1 - a_{12}X_2 - \dots - a_{1m}X_m = x_{1n}\\
&- a_{21}X_1 + X_2 - a_{22}X_2 - \dots - a_{2m}X_m = x_{2n}\\
&\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\\
&\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\\
&\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\\
&- a_{m1}X_1 - a_{m2}X_2 - a_{m3}X_3 - \dots + X_m = x_{mn}
\end{aligned} \qquad \text{(II - 3)}$$

briefly,

$$\begin{bmatrix} X_i \end{bmatrix} - \begin{bmatrix} a_{ij} \end{bmatrix} \begin{bmatrix} X_j \end{bmatrix} = \begin{bmatrix} x_{in} \end{bmatrix} \quad \text{or,}$$

$$\left\{ \begin{bmatrix} I \end{bmatrix} - \begin{bmatrix} a_{ij} \end{bmatrix} \right\} \begin{bmatrix} X_i \end{bmatrix} = \begin{bmatrix} x_{in} \end{bmatrix}$$

where, $\left[a_{ij} \right]$ is the so-called input-output coefficient matrix, and $\left[I \right]$, an identity matrix. The solution of the system of equation (II - 3) can be written in the following form:

$$
\begin{aligned}
X_1 &= A_{11}x_{1n} + A_{12}x_{2n} + \ldots + A_{1m}x_{mn} \\
X_2 &= A_{21}x_{1n} + A_{22}x_{2n} + \ldots + A_{2m}x_{mn} \\
&\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
&\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots, \\
&\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
X_m &= A_{m1}x_{1n} + A_{m2}x_{2n} + \ldots + A_{mm}x_{mn}
\end{aligned}
\qquad \text{(II - 4)}
$$

or, simply,

$$\left[X_i \right] = \left[A_{ij} \right] \left[x_{in} \right]$$

where $\left[A_{ij} \right] = \left\{ \left[I \right] - \left[a_{ij} \right] \right\}^{-1}$. This is what we call the interdependence coefficient matrix.

The input-output or technical input coefficients, a_{ij}, tells us what amount of product i should be used to produce a unit of product j, while the interdependence coefficients A_{ij}, specifies the required change in gross output of industry i for a one-unit change in the amount of good delivered to final demand by industry j. So far, the sine qua non of the input-output model has been established.

To briefly review the nature of the model, we can see that it does not present a theoretically complete picture of either the supply or the demand side of the economy, in that it does not envision optimizing behaviour on the part of economic organisms faced with alternative courses of action. Like other production functions, it deals with technology only, not with the preference of economic organism among different states of

affairs. The similarity of the model to a general equilibrium system is that it encompasses all products and industries, rather than singling out one or a few for study and relegating the others to the pound of ceteris paribus. And yet, Leontief's input-output model is unlike general equilibrium system in that it is not in itself an equilibrium system.

Underlying assumptions. Systems of general market equilibrium are too detailed to serve as a basis of empirical application. Leontief's approach was to simplify the Walrasian system to the extent necessary to derive a set of parameters for his model from a single observation of each of the inter-industry transactions in the economy. Hence, some basic assumptions are made, which can be stated under the following two categories:

A. For descriptive analysis:

1. Given consumption function,
2. Pure competition and free entry,
3. The industry(sector), rather than the firm is the unit of production,
4. Constant input-output coefficients,
5. Only one output in any industry(sector), and a different output for each industry,
6. No errors of aggregation exist,
7. Only current flows of inputs and outputs are important, i.e., that problems of capacity and capital can be safely ignored.

B. For projections:

8. A fixed mix of products,

9. A fixed mix of inputs, and,

10. A fixed mix of final deliveries.

Much has been written criticizing these restrictive assumptions of the model. The most criticized one is the linearity assumption on the relationship between input and output, which implies, (1) constant technology, (2) constant return to scale, and (3) no substitution possibility in terms of both inputs and outputs. Nevertheless, Cameron concludes, after studying production processes for 178 Australian industry subclasses, that the assumption of fixed production coefficients may be a reasonable approximation of the true relationship.[12] Nonproportional inputs, changes in product-mix, input substitutions, and technological changes all do occur beyond any question. The really important question, therefore, is an empirical one: are the errors involved in using this simplifying assumption satisfactorily small? Chenery and Clark[13] in a broad review of the accomplishments in this area infer that

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[12] B. Cameron, "The production function in Leontief models," Review of Economic Studies, vol. 20 (1953), 62-69.

[13] H. B. Chenery and P. G. Clark, Interindustry Economics, John Wiley & Sons, Inc., N. T., 1959.

because of the properties of input-output matrices, errors in the coefficients do not lead to cumulative errors in the solutions, but on the contrary tend to compensate for each other; the most important coefficients should be investigated and additional attention devoted to quantifying them, while assuming small errors in the great bulk of the coefficients will not cause difficulties. However, due to continuing technological changes, it is advisable to make complete or partial revisions of input-output tables every four or five years.

Although the assumptions thus made limit the usefulness of the model greatly, Leontief's input-output analysis has been indeed the sole applicable tool available for handling problems that require a picture of the production function of the entire economy, and its results can serve as first approximations from which to start making corrections where special information permits or experience demands.

The merit of Leontief's input-output model consists in its capacity to quantify the structural interdependence of an economy. "Structural", according to the Oxford Dictionary, denotes something "pertaining to the arrangement and mutual relation of the parts of any complex unity." The parts of a national economy, for example, are individual households, business firms, industrial plants, or processes within plants, or group of such units, or various levels of governments. These different sectors of the economy consume each others'

products. For this reason, the level of activity in the different sectors must be mutually consistent to ensure the smooth operation of the economy towards its goals -- whether these goals are postulated by a central planning organ or are the outcome of the interaction of market forces. In this sense the economy is structurally interdependent. Insofar as the "planning" or "control" has increasingly become important in modern economic activities, measurement of this sets of relationships is highly useful and desirable.

CHAPER III

THE MODEL FOR THE LIVESTOCK INDUSTRY IN CANADA

In the previous chapter, the basic input-output model has been discussed. The possibilities for more complex formulations to increase the realism of the system are very wide, but most of them can be treated as generalizations of this simple model. The factors which dictate the number and nature of the variables, and hence, the kind of model to be employed are: (1) the problem, or subject-matter, (2) the objective of the study, and (3) the availability of data.

As mentioned in Chapter I, the subject-matter of this study is the livestock industry in Canada. All variables and aggregation involved will, therefore, be either directly or indirectly related to this industry. A more ambitious model which includes regional sectors had been attempted in the early stage of this study. Unfortunately, due to lack of most regional data and limited amount of time available, only the model at the national level could be approached in the present study. The following are definitions and classifications of various sectors as well as the theoretical background of special models which will concern us.

Definitions and Classifications of the Economic Model

As input-output analysis is aimed at a study of interrelationships between various parts of an economy, establishment or definitions and classifications of these various interrelated parts called sectors is not only a prerequisite for collecting data, but also a necessary reference in interpreting results obtained in later part of the work. The special model built for the purposes on hand has three major sectors: (1) intermediate sectors, (2) the unallocated sector, and (3) final demand sectors. Sectors included in the first group are endogenous in the sense that each sector is a producing unit as well as a consuming unit. They are functionally interdependent. Sectors in the latter two groups are exogenous to the system in that their levels of activities are dependent on forces outside of the model. Brief definitions of the commodity or industry included in each sector are given below:

Intermediate sectors.

ML 1 Cattle and Calves -- this and the immediate following sector "Hogs" are of primary interest in the study. They are the only sectors designated as livestock production.

ML 2 Hogs.

ML 3 Feed Grains -- the sector comprises of corn, oats, barley and mixed grains. This and the rest of sectors in the group are considered as input sectors to livestock production.

ML 4 Food Grains -- the sector includes wheat, rye, and buckwheat. It is interesting to specify this sector from the point of view that livestock compete with people in consuming these crops.

ML 5 Forage Crops -- fodder corn, tame hay, and pasture are the items in this sector.

ML 6 Meat Processing -- the components of this sector are the products of Slaughtering and Meat Processors as classified in DBS publications, Cat. No. 32-221, which includes products of slaughtering and meat packing plants, sausage and sausage casings manufacturers and animal oils and fats plants.

ML 7 Prepared Feeds -- products of Feed Manufacturers, DBS, Cat. No. 32-214, are included in this sector.

ML 8 Machinery and Related Services -- with respect to agriculture, tractors, farm machinery, motor vehicles, gasoline, oil, grease and related services are the components of this sector.

The unallocated sector. This sector was designed as a balancing sector which exhausts the output of each aforementioned sector. The notation for the sector is ML 9.

Final demand sectors. Components of this group are foreign trade (exports and imports), inventories, government, and household consumption.

ML 10 Foreign Trade -- exports include sales of goods and services from Canada-sectors for use abroad. It is assumed that all imports are substitutable for some domestic product, and hence, they are treated as competitive. Imports are distributed as if they are secondary products of foreign trade and channeled to the industries for which their products are primary. Although study on impacts on the import sector is a very interesting one, unfortunately, lack of detailed import data by uses prevents its presence. Exports and imports are distinguished by subscripts 'a' and 'b'.

ML 11 Inventory -- inventory accounts are established to facilitate reconciliation of current production with current consumption. Figures on inventory changes of each sector are entered in this column. It may be positive or negative. In case of negative figures, they are excluded in calculating domestic gross output of each sector.

ML 12 Government -- in this open input-output model the government sector is of minor significance in the sense that there is little transaction associated with it.

ML 13 Household Consumption -- this sector includes all purchases by the household sector. Farm income in kind is also included. The only flow from this sector to other sectors considered in this study is wages and salaries designated as "labor", and denoted as sector $ML13_b$.

Theoretical Background

The theoretical or mathematical formulation of the previous economic model has been derived from the basic input-output model presented in Chapter II, along with some extensions and applications, as follows:

If we denote gross domestic output of each producing sector as X_i; the output of i producing sector purchased by j producing sector as x_{ij}; and the output of i producing sector purchased by exogenous sectors as x_i^k; the following transaction system of equations are obtained:

$$
\begin{aligned}
X_1 &= x_{11} + x_{12} + \cdots + x_{18} + x_1^9 + \cdots + x_1^{13} \\
X_2 &= x_{21} + x_{22} + \cdots + x_{22} + x_2^9 + \cdots + x_2^{13} \\
&\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
&\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
&\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
X_8 &= x_{81} + x_{82} + \cdots + x_{88} + x_8^9 + \cdots + x_8^{13}
\end{aligned}
\qquad \text{(III-1)}
$$

or, concisely written as,

$$(III\text{-}2) \quad X_i = \sum_j x_{ij} + \sum_k x_i^k \,, \quad \text{where } i, j = 1,2,\ldots,8 \quad k = 9,10,\ldots,13$$

With the basic assumption of linearity regarding the relationships between inputs and output of each producing sector, we have these fixed technical coefficients:[14]

$$(III\text{-}3) \quad a_{ij} = \frac{x_{ij}}{X_j} \,, \text{ or } x_{ij} = a_{ij} X_j$$

Substituting (III-3) into (III-2), we obtain,

$$X_i = \sum_j a_{ij} X_j + \sum_k x_j^k \,, \text{ or}$$

$$(III\text{-}4) \quad \sum_k x_i^k = X_i - \sum_j a_{ij} X_j$$

Aggregating purchases of all exogenous sectors into one single sector, (III-4) can be rewritten as,

$$F_i = X_i - \sum_j a_{ij} X_j \,, \text{ or in matrix notation,}$$

$$(III\text{-}5) \quad F = (I - A)X$$

Solving (III-5) for the required outputs of each sector in terms of F_i gives (III-6),

$$(III\text{-}6) \quad X = (I - A)^{-1} F$$

where A represents technical coefficient matrix; and $(I - A)^{-1}$, interdependence coefficient matrix.

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[14] If $x_{ij} = a_{ij} X_j + c_{ij}$ is adopted as the type of relationship between input and output, c_{ij} is further assumed zero for simplicity.

Some Extensions and Applications of the Model

Before leaving this chapter, it seems appropriate to discuss here some extensions and applications of the model to be employed in the present study. The flexibility of the input-output model lies not only in adapting the model itself to specific objectives of the study and to the availability of data as briefly mentioned above, but also in its use in conjunction with other quantitative analysis. This is particularly evident when more realistic results necessary for policy-making are required.

Direct vs. indirect input requirements. The direct and indirect effects of output changes can be derived by dividing each column entry in the interdependence coefficient matrix by that column's diagonal element. If A_{ij} is used to denote element in the matrix, it is divided by its corresponding A_{ij}, for $i = j$. The quotients except all 1's on the diagonal can then be compared with technical coefficients and the magnitude of the indirect input requirements of one sector per dollar of its output obtained.

Structural analysis. From the standpoint of the inter-industry method, structural analysis consists logically in various ways of studying the interdependence coefficient matrix: (1) If one wishes to study the ultimate impact of demand for a commodity (product of a producing sector), one

only has to read down the appropriate column. The total of each column is sometimes called the output multiplier, since it can be used to derive required output changes due to changes in final demand. In algebraic terms, this can be expressed as,

$$(III\text{-}7) \qquad \sum_{i}^{s} \Delta X_i = \left(\sum_{i}^{s} A_{ij}\right) \Delta F_j$$

where A_{ij} is the output multiplier. (2) If one is interested in a composite structural analysis, involving a particular cluster of final demands, one can do this by multiplying the columns by appropriate weights. The total effects on output requirement of each sector can then be summed up. (3) Another aspect of structural analysis is the examination of structural changes over time. This type of analysis can be conducted on both flow tables and technical coefficient tables or different time periods concerned. Relative changes in the flows or input coefficients over time reflect both changes in techniques and changes in the combination of factors used in producing the output of a particular sector. One requirement is that constant dollar be used for all tables.

Backward projection. There are two cases in which backward projection can be applied. One is in testing the validity of the original Leontief assumption of constant input ratios, or coefficients for input-output analysis.[15]

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[15] Leontief, op. cit. Part IV-A.

The other is in observing aggregate technical change over time.[16] The first case does not concern us here. For the latter, the procedure is to project output of a certain past period by using the final bill of goods of that period along with the interdependence coefficient matrix of a later period.[17] If the projected output is the same as actual output, no technical change has taken place; a large difference denotes great technical change.

Forward projection. The logic of this application is much the same as the backward projection just discussed, except that we are now interested in projecting the output of a certain future period on the final bill of goods of that future period. Information on the final bill of goods now has to be obtained either from the projection made by other studies, or by one's own study. Two independent projections are involved. The scope of the input-output projection may include the entire final bill of goods or only part of it. This type of application is mostly policy-oriented. There are a number of instances of overall economic projections in

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[16] G. A. Peterson and E. O. Heady, Application of Input-Output Analysis to a Simple Model Emphasizing Agriculture, Iowa Agr. Expt. Sta. Res. Bul. 427, 1955.

[17] The system of equations to be applied is (II-4) or (III-6).

the published interindustry literature, such as the study by Cornfield, Evans, and Hoffenberg (1947)[18]; by Berman (1953)[19]; by Chenery, Clark, and Cao-Pinna (1953)[20]. Carter and Heady made a partial projection on their 1954 input-output structures for 1960 and 1975.[21]

Total and direct labor requirements. In an open input-output framework, labor along with imports, capital and land are treated as primary resources which do not enter the interdependent system. Nevertheless, input requirements of these primary resources for a certain bill of goods can also be derived as follows, provided that we know the functional relationships between outputs and these inputs:

Labor requirements, for example. Assuming the functional relationship, $x_{oi} = a_{oi}X_i + c$, and ignoring c for the moment, total labor requirements of a sector can be derived from the projected output of that sector, i.e.,

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[18] J. Cornfield, W. D. Evans, and M. Hoffenberg, "Full Employment Patterns, 1950, Monthly Labor Review, LXIV, No. 2, 163-190 (Feb., 1947), and LXIV, No. 3, 420-432 (March, 1947).

[19] E. B. Berman, "The 1955 and 1975 Interindustry Final Bills and Generated Activity Levels", Interindustry Item No. 16, U. S. Bureau of Mines, 1953.

[20] H. B. Chenery, P. G. Clark, and V. Cao-Pinna, The Structure and Growth of the Italian Economy, U. S. Mutual Security Agency, Rome, 1953.

[21] Carter and Heady, op. cit., 522-25.

(III-8) $$X_i = \sum_{j=1}^{m} A_{ij}F_j,$$

(III-9) $$x_{oi} = a_{oi}X_i = a_{oi}\sum_{j=1}^{m} A_{ij}F_j, \text{ and}$$

direct labor requirements are, $a_{oi}A_{ij}F_j$, where $i = j$.

Total labor requirements of a sector include not only employment in a sector induced directly by the final demand for output of that sector, but also employment required of that sector induced indirectly by the final demand for outputs of other sectors.

CHAPTER IV

EMPIRICAL RESULTS FOR THE 1961 MODEL

Based on the model or theoretical background set up for the livestock industry in Canada in Chapter III essential sets of tables which will serve in later analysis have been compiled: viz., the flow tables, the technical or input-output coefficient tables and the interdependence tables. Since there is close relationships between tables of the same set, only the use and structure of those of Model I and for 1961 are described in this chapter. The development of models and sources of data will be given in the Appendix. Understanding of these tables will help greatly in following the exposition of further analysis.

The flow tables. These are the tables which describe the transactions between different sectors. The formal counterparts of the tables are the systems of equations (II - I) and (III - I). In contrast to these systems of equations total output of each sector is placed in the extreme right column. In Table III the first eight rows show the distribution of product of each sector named in the extreme left column to various sectors named on the top of each column. For example, of $687,065,000 value of total output of 'cattle' sector (ML1), $50,041,000 was purchased as feeder cattle by the sector itself; $335,981,000 was delivered as slaughter

TABLE III

TRANSACTION TABLE, LIVESTOCK INDUSTRY, CANADA, MODEL I, 1961
(Thousand dollars at producers' prices)

Sector	I Cattle	II Hogs	III Feed Grains	IV Food Grains	V Forage Crops	VI Meat Processing	VII Prepared Feeds	VIII Machinery & Rel.Sv.	IX_a Unallocated Outputs	X Exports	X Imports
I	50,041	-	-	-	-	335,981	-	-	164,566	85,640	-1,294
II	-	1,951	-	-	-	247,766	-	-	70,448	1,169	-
III	40,386	158,588	31,663	-	-	-	54,237	-	43,311	41,084	-34,449
IV	1,070	10,716	-	66,296	-	-	21,102	-	154,288	564,011*	-12
V	210,118	2,447	-	-	-	-	1,272	-	254,785	1,197	-1,413
VI	106	106	-	-	-	178,523	10,932	-	3,109	64,345	-85,419
VII	28,050	63,023	-	-	-	255	849	-	195,126	1,908	-336
VIII	27,266	10,179	118,856	140,369	110,748	12,748	3,325	37,813	578,198	..	..
IX_b**	295,928	76,940	251,695	282,232	346,358	231,737	185,948	2,651,726	..	4,442,002	-6,327,552
$XIII_b$+	34,100	16,900	19,500	5,800	11,300	120,409	24,513	574,548	15,137,730	..	..
G.D.I.++	687,065	340,850	421,714	494,697	468,406	1,127,419	302,178	3,264,087	..	5,201,356	-6,450,475

TABLE III (continued)

Sector	Inventory Changes	XII Government	$XIII_a$ Household Consumption	Gross Domestic Output
I	+ 31,902	-	20,229	687,065
II	+ 4,325	-	15,191	340,850
III	+ 86,894	-	..	421,714
IV	+ 241,237	-	..	494,697
V	-	-	-	468,406
VI	+ 2,509	..	953,208	1,127,419
VII	+ 327	-	12,976	302,178
VIII	+ 13,585	112,000	2,099,000	3,264,087
IX_b**	..	7,393,000	24,532,396	..
$XIII_b$+	-	3,594,000	889,000	19,539,000
G.D.I.++	+ 30,000	11,099,000	28,522,000	...

* Export of food grains was supposed to come entirely from year-to-year carryover.
** 'Unallocated Inputs' sector: Each cell in this row is the difference between the gross domestic inputs and the sum of inputs for each and the same column.
\+ 'Labor' sector.
++ G.D.I. stands for 'Gross Domestic Inputs'.

animal to Meat processors (ML6). $85,640,000 worth was sold abroad (ML10); inventory change on farms (ML11) was in the amount of $31,902,000; and only $20,229,000 worth was slaughtered and consumed on farms (ML13). On the other hand, $1,294,000 worth of cattle was imported during the same period (ML10). As in most of input-output analysis, producers' prices were used in this study. In addition to eight rows for intermediate sectors 'labor' row ($ML13_b$) was added to the table. Since an open input-output model was employed in this study household consumption was treated as one of the final demand sectors.

As pure competition and free entry is assumed for the model, there must be balance for each intermediate sector. In other words, gross domestic output must be equal to gross domestic input for each intermediate sector. Column 9_a and row 9_b are different as apparent in their captions. One refers to output, the other to input. They need not be of the same magnitude for each intermediate sector. Both vary with the number and kind of sectors concerned. However, the column total of 9a should be equal to the row total of 9_b.

Reading from the top of columns 1 through 8 down the bottom of the same columns, we have the cost structure for each intermediate sector. The 'hogs' sector (ML2), for example, bought feeder hogs through public stockyards at the cost of $1,951,000; cost for feed grains (ML3) was $158,588,000

which constituted the largest part of cost incurred in hog production; the second largest individual cost item was prepared feeds (ML7), $63,023,000; cost for food grains (ML4) fed to hogs was $10,716,000; forage crops (ML5) fed to hogs was in the amount of $2,447,000; while cost incurred on machinery and related services (ML8) in hog production amounted to $10,179,000. Labor ($ML13_b$) employed in hog production was valued at $16,900,000. For other cost items such as rent, taxes, etc. the amount was $76,940,000.

Specific examples of correspondence with the system of equations (III-I) are as follows. Internal inputs ($1,951,000) equals X_{22}; inputs from 'feed grains' sector ($158,588,000) equals X_{32}; etc. Similary, for row entries, output of 'cattle' sector purchased internally ($50,041,000) equals to X_{11}; purchases of 'meat processing' sector from 'cattle' sector ($335,981,000) equals to X_{16}, etc. Tables of similar construction to Table III are Tables VII and XIII. One is for the second input-output model, the other for different time periods.

Technical coefficients. Table IV shows technical or input-output coefficients for each intermediate sector. Exogenous sectors are excluded here since they are not interrelated with each other nor are they related to the intermediate sectors. Labor, as a primary input, however, is shown in relation to the output of each intermediate sector.

Reading across the table, say, 'feed grains' sectors, each entry tells us the direct requirement for the output of this sector of the sector named at the top of each column. For each dollar output of the 'cattle' sector (ML1) 6 cents worth of feed grains (ML3) was required; for each dollar worth of hogs (ML2), 47 cents worth of feed grain (ML3) was required, etc. On the other hand, if we read down each column of the table, we obtain the input structure in terms of a $1 worth output for each sector named at the top of the corresponding column. In order to produce a $1 worth of output of 'cattle' sector (ML1) the following amounts of inputs were directly required: 7 cents worth of feeder cattle (ML1) through public stockyards, 6 cents worth of feed grains (ML3); 0.2 cents worth of food grains (ML4); 31 cents worth of forage crops (ML5); 4 cents worth each of prepared feeds (ML7) and machinery and related services (ML8); and 5 cents worth of labor ($ML13_b$).

Entries in Table IV were calculated directly from Table III by dividing figures in each column with the total domestic output of the sector named at the top of the corresponding column. Each entry thus corresponds a_{ij} in the sets of equations (III - 3). Similar tables are Tables VIII, and XIV. The importance of Table IV and similar tables lies not only in that they indicate the level of technology, provide input composition for a $1 worth of output of each inter-

mediate sector, but also in that relevant interdependence coefficients were derived from them.

Interdependence coefficients. Entries in Table V are elements of the inverse matrix of equation (III - 6) or b_{ij} of the system of equations (II - 4). The unique feature of this matrix is that indirect and circular relationships between sectors, as well as the direct relationships, are summarized. Each coefficient shows the direct and indirect requirements for products of the row sector per dollar of delivery to final demand of products of the column sector. Thus, a dollar's worth of final demand for products of 'hogs' sector (ML2) was associated with the following outputs of the sectors listed on the extreme left. 0.3 cents from the 'cattle' sector (ML1); one dollar and 0.8 cents from itself (one dollar for final demand plus 0.8 cents' worth of generated internal flows); 54 cents from feed grains (ML3); 5 cents from food grains (ML4); about 1 cent each from forage crops and meat processing (ML5 and ML6); 19 cents from prepared feed (ML7) and 20 cents from machinery and related services (ML8). The association of a dollar's final demand for products of a sector other than 'hogs' can be examined in the analogical manner.

TABLE IV

INPUT-OUTPUT COEFFICIENTS LIVESTOCK INDUSTRY CANADA
MODEL I 1961

SECTOR	I CATTLE	II HOGS	III FEED GRAINS	IV FOOD GRAINS	V FORAGE CROPS	VI MEAT PROC	VII PREP FEEDS	VIII MACH & REL SV
CATTLE	0.072833	0.0	0.0	0.0	0.0	0.298009	0.0	0.0
HOGS	0.0	0.005724	0.0	0.0	0.0	0.219764	0.0	0.0
FEED GRAINS	0.058781	0.465272	0.075082	0.0	0.0	0.0	0.179487	0.0
FOOD GRAINS	0.001557	0.031439	0.0	0.134013	0.0	0.0	0.069833	0.0
FORAGE CROPS	0.305820	0.007179	0.0	0.0	0.0	0.0	0.004209	0.0
MEAT PROC	0.000154	0.000311	0.0	0.0	0.0	0.158347	0.036177	0.0
PREP FEEDS	0.040826	0.184900	0.0	0.0	0.0	0.000226	0.002810	0.0
MACH & REL SV	0.039685	0.029864	0.281840	0.283747	0.236436	0.011307	0.011003	0.011585
LABOR	0.049631	0.049582	0.046240	0.011724	0.024124	0.106801	0.081121	0.176021

TABLE V

INTERDEPENDENCE COEFFICIENTS LIVESTOCK INDUSTRY CANADA
MODEL I 1961

SECTOR	I CATTLE	II HOGS	III FEED GRAINS	IV FOOD GRAINS	V FORAGE CROPS	VI MEAT PROC	VII PREP FEEDS	VIII MACH & REL SV
CATTLE	1.079227	0.002703	0.0	0.0	0.0	0.382838	0.013889	0.0
HOGS	0.000464	1.007613	0.0	0.0	0.0	0.263265	0.009551	0.0
FEED GRAINS	0.077412	0.543322	1.081177	0.0	0.0	0.169330	0.200747	0.0
FOOD GRAINS	0.005527	0.051661	0.0	1.154752	0.0	0.015468	0.081428	0.0
FORAGE CROPS	0.330240	0.008847	0.0	0.0	1.000000	0.119242	0.008547	0.0
MEAT PROC	0.002101	0.008408	0.0	0.0	0.0	1.191089	0.043211	0.0
PREP FEEDS	0.044271	0.186946	0.0	0.0	0.0	0.064759	1.005165	0.0
MACH & REL SV	0.146518	0.204601	0.308290	0.331498	0.239207	0.118919	0.095192	1.011721

CHAPTER V

ECONOMIC IMPLICATIONS OF INPUT-OUTPUT MODELS

Although this study has placed more emphasis on the possible development of livestock industry in Canada by 1975, further consideration would reveal that collection of facts concerning the situation of the livestock industry in relation to other industries is by no means far from necessary. These two aspects are complementary to each other in facilitating scientific policy-making in secondary agriculture for the decade to come. One of the major applications of the input-output model is the analysis of the economic structure. After having presented the compilation and mechanical meanings of the basic input-output tables in the previous chapter, this chapter is devoted to the analysis of the economic implications of the models especially set up for the livestock industry in Canada. It is to be noted that any analysis or interpretation of specific sectors must be viewed in the perspective in which these sectors were constructed, not as individual contributions but as part of a complete model.

Transaction patterns. Table VI, showing the percentage distributions of total supplies or what is, sometimes, called the distribution coefficients, was calculated from Table III, the transactions table. Total supplies consist of both domestic production and imports of each commodity concerned.

For example, total supply of meat products amounted to $1,212,838,000 in 1961 while gross domestic production was $1,127,419,000 for the same year. This table shows us the general transaction patterns of the livestock industry and other related industries.

In 1961 half of cattle production went to slaughtering and meat processors. Slightly more than 12 percent was exported. Around 7 percent was feeder cattle marketed through public stockyards. Cattle slaughtered and consumed on farms took only 3 percent. The rest of the percentages were feeder cattle sold through markets other than public stockyards and cattle slaughtered in small establishments. They were not counted here because of lack of data. Imports of cattle in the value of $1,294,000 were primarily for breeding purposes.

Most production of hogs were slaughtered in this country. Export of live hogs assumed little significance. It took only 0.3 percent of total production. Marketing of feeder hogs were even more scarce through public stockyards than feeder cattle. In contrast to marketing of feeder cattle, very few of feeder hogs were shipped outside of the province where they were raised. A little higher percentage, 4.5 percent of hogs were slaughtered and consumed on farms. No live hogs were imported in 1961.

Thirty-five percent of the feed grains produced in 1961 was fed to hogs, 9 percent to cattle. About 12 percent of

TABLE VI

PERCENTAGE DISTRIBUTIONS OF TOTAL SUPPLIES
LIVESTOCK INDUSTRY, CANADA,
MODEL I, 1961

Sector	I Cattle	II Hogs	III Feed Grains	IV Food Grains	V Forage Crops	VI Meat Processing	VII Prepared Feeds	VIII Machinery & Rel.Sv.
I	7.27	-	-	-	-	48.81	-	-
II	-	0.57	-	-	-	72.69	-	-
III	8.85	34.77	6.94	-	-	-	11.89	-
IV	0.22	2.17	-	13.40	-	-	4.27	-
V	44.72	0.52	-	-	-	-	0.27	-
VI	-	-	-	-	-	14.72	0.90	-
VII	9.27	20.83	-	-	-	0.08	0.28	-
VIII	0.84	0.31	3.64	4.30	3.39	0.39	0.10	1.16
$XIII_b$ **	38.93	19.29	22.26	6.62	12.90	-	-	-

TABLE VI (continued)

Sector	IX Unallocated Outputs	X Exports	XI Inventory Changes	XII Government	$XIII_a$ Household Consumption	Gross Domestic Output
I	23.91	12.44	4.63	-	2.94	100.00
II	20.67	0.34	1.27	-	4.46	100.00
III	9.49	9.01	19.05	-	..	100.00
IV	31.19	*	48.76	-	..	100.00
V	54.23	0.25	-	-	-	100.00
VI	0.26	5.31	0.21	-	78.59	100.00
VII	64.50	0.63	0.11	-	4.29	100.00
VIII	17.71	..	0.42	3.43	64.31	100.00
$XIII_b$ **	-	-	-	-	-	-

* Export of food grains was supposed to come entirely from year-to-year carryover.

** $XIII_b$ stands for 'Labor' sector, only percentages of total labor employed in agriculture (sectors 1 - 5) amounting to $87,600,000 are calculated here.

these grains went to the prepared feeds industry. A small portion of food grains production was used in secondary agriculture: 4 percent of it was shipped to prepared feeds industry; 2 percent was consumed by hogs; and only 0.2 percent fed to cattle. Estimation of the percentage of forage crops consumed by cattle was 45 percent of the total supply. As little as 0.5 percent was estimated to be consumed by hogs. Another big consumer of forage crops is dairy cows which is not considered in this study.

The meat processing industry is one of the big agricultural processing industries, which absorbs a large amount of products from the agricultural sector but in return sells little of its products to agriculture. Most of its products are final products delivered to final demand sectors. As much as 80 percent of the total supply of meat products was consumed by the household sector in 1961. There were intra-sectoral transactions amounting to 15 percent of the total supply. On the other hand, a greater percentage of products of the 'prepared feeds' sector were delivered to the agricultural sectors than was the case for products from the meat processing industry. The prepared feed industry is somewhat of a dual-purpose industry since it both processes grain and furnishes large quantities of formula feeds to agricultural sectors. The estimate on delivery of prepared feeds to the 'hogs' sector is 21 percent of total supply. Nine percent was delivered to the

'cattle' sector.

Compared to primary agriculture, the degree of mechanization is far less in livestock production. We can see this in Table VII. While the expenditure of primary agriculture on machinery and related services amounted to $369,973,000 in 1961, the same expenditure of livestock production was $37,445,000, only one-tenth of that incurred in primary agriculture. A large quantity of goods and services produced by the 'machinery and related services' sector was sold to the 'household consumption' sector. It accounted for 64 percent of the total production. Percentages distributed to each agricultural sector are as follows: 4.3 percent to the 'food grains' sector; 3.6 percent to the 'feed grains' sector; 3.4 percent to the 'forage crops' sector; only 0.8 percent and 0.3 percent to the 'cattle' sector and 'hogs' sector, respectively. Consequently, secondary agriculture is more labor-consuming than the primary agriculture. Of the total labor employed in agriculture amounting to $87,600,000, 38.9 percent was employed by the 'cattle' sector. Hog production used lesser amount of labor, 19.29 percent. It is amazing that only 6.6 percent of total labor employed in agriculture was for production of food grains.

Direct dependence between sectors. A question in the agricultural economy is that of the inter-relation of crop and livestock production. What are the requirements placed on

TABLE VII

TRANSACTION TABLE, LIVESTOCK INDUSTRY
CANADA, MODEL II, 1961
(Thousand dollars at producers' prices)

Sector	I Secondary Agriculture	II Primary Agriculture	III Meat Processing & Feed Industry	IV Machinery & Related Services	V_a Unallocated Outputs
I	51,992	-	583,747	-	235,014
II	423,325	97,959	76,611	-	452,384
III	91,285	-	190,559	-	198,235
IV	37,445	369,973	16,073	37,813	578,198
V_b **	372,868	880,285	417,685	2,651,726	..
IX_b	51,000	36,600	144,922	574,548	15,137,730
G.D.I.	1,027,915	1,384,817	1,429,597	3,264,087	..

TABLE VII (continued)

Sector	VI_a Exports	VI_b Imports	VII Inventory Changes	VIII Government	IX_a Household Consumption	Gross Domestic Outputs
I	86,809	-1,294	36,227	-	35,420	1,027,915
II	42,281*	-35,874	328,131	-	..	1,384,817
III	66,253	-85,755	2,836	..	966,184	1,429,597
IV	..	..	13,585	112,000	2,099,000	3,264,087
V_b **	4,442,002	-6,327,552	..	7,393,000	24,532,396	..
IX_b	..	..	-	3,594,000	889,000	19,539,000
G.D.I.	5,201,356	-6,450,475	30,000	11,099,000	28,522,000	..

* Only exports of Feed grains and forage crops were counted here.
** 'Unallocated Inputs' sector; 'Labor Inputs' sector.
† G.D.I. stands for 'Gross Domestic Inputs'.

primary agriculture when secondary production is increasing? What amount of crop product from primary agriculture is necessary for each "unit increase" in output of livestock? More specifically, what amount of feed grains, for example, will be required for a unit increase in hog production? What amount of forage crops will be needed for a unit increase in cattle production?

All these questions and questions of similar nature can be answered by examining Table IV in the previous chapter and Table VIII in this chapter. It is apparent in Table VIII that there exists a close relation between primary and secondary agriculture. For a dollar increase in secondary production 41 cents of inputs from primary agriculture was required in 1961. Some of the other requirements were 9 cents of products from 'meats and feeds' aggregate sector, and 4 cents of outputs from 'machinery and related services' sector.

TABLE VIII

INPUT-OUTPUT COEFFICIENTS, LIVESTOCK INDUSTRY CANADA, MODEL II, 1961

Sector	I	II	III	IV
I Secondary Agriculture	0.050580	-	0.408330	-
II Primary Agriculture	0.411829	0.070738	0.053589	-
III Meats and Feeds	0.088806	-	0.133296	-
IV Machinery & Rel. Services	0.036428	0.267164	0.011243	0.011585

To consider cattle and hog production separately, for each dollar worth of cattle production inputs from the 'forage crops' sector amounted to 31 cents. Costs of feeder cattle from public stockyards was 7 cents, feed grains 6 cents, 4 cents each from prepared feeds and machinery services, respectively. The cost structure of hog production was quite different from that of cattle production except that they both required a similar amount of labor input, 5 cents for each dollar worth of output. As mentioned before, a great portion of the cost for producing hogs was due to feed grains. They required 50 cents worth of feed grains for each dollar worth of output. Inputs of hog production from 'prepared feeds' sector were 18 cents per each dollar of output. Products of 'food grains' sector used for feed were mostly fed to hogs rather than to cattle, amounting to 3 cents for each dollar worth of output. Costs incurred on machinery and related services was 1 cent less than that for cattle production. Also shown in these two Tables are the direct requirements of production in so-called agri-business for products from agricultural sectors. In aggregate, each dollar increase of production in the 'meats and feeds' sectors required 41 cents worth of products from secondary agriculture, while only 5 cents worth of products from primary agriculture. In detail, these requirements were: 30 cents worth of products from the 'cattle' sector and 22 cents worth of products from the 'hog' sector for production of a dollar worth of output in

meat processing industry; 18 cents worth and 7 cents worth of products from food and feed grains sectors for producing a dollar worth of output in the 'prepared feeds' sector. Labor requirement in the meat processing industry was higher than that in the prepared feeds industry. The former required 11 cents per one dollar worth of output while for the latter, only 8 cents was required. The reason for this may lie partly in the 'guaranteed wages' set up for workers employed by the meat processing industry.

Interdependence between sectors. Output requirements for a sector are not only determined by the final demand for that sector, but also arise from the final demand for outputs of other sectors. Hence there exists interdependency between sectors. One measurement of this relationship is the "ratios of indirect to direct requirement". To obtain these ratios the interdependence coefficients in Table V of the proceeding chapter were first adjusted to reflect changes in output rather than final demand and are presented in Table IX. If coefficients from Table IV are subtracted from corresponding coefficients (excluding those in the diagonal) in Table IX to obtain only the indirect requirements generated by changes in outputs, a table of ratios of indirect to direct effects may be computed. These ratios are presented as Table X. Each entry is the proportion that indirect requirements of the column sector for products of the row sector are of the corresponding direct requirements.

TABLE IX

ADJUSTED INTERDEPENDENCE COEFFICIENTS LIVESTOCK INDUSTRY CANADA
MODEL I 1961

SECTOR	I CATTLE	II HOGS	III FEED GRAINS	IV FOOD GRAINS	V FORAGE CROPS	VI MEAT PROC	VII PREP FEEDS	VIII MACH & REL SV
CATTLE	1.000000	0.002680	0.0	0.0	0.0	0.321420	0.013820	0.0
HOGS	0.000430	1.000000	0.0	0.0	0.0	0.221030	0.009500	0.0
FEED GRAINS	0.071730	0.539220	1.000000	0.0	0.0	0.142160	0.199720	0.0
FOOD GRAINS	0.005120	0.051270	0.0	1.000000	0.0	0.012990	0.081010	0.0
FORAGE CROPS	0.306000	0.008780	0.0	0.0	1.000000	0.100110	0.008500	0.0
MEAT PROC	0.001950	0.008340	0.0	0.0	0.0	1.000000	0.042990	0.0
PREP FEEDS	0.041020	0.185530	0.0	0.0	0.0	0.054370	1.000000	0.0
MACH & REL SV	0.135760	0.203060	0.285140	0.287070	0.239210	0.099840	0.094700	1.000000

TABLE X

RATIOS OF INDIRECT TO DIRECT REQUIREMENTS LIVESTOCK INDUSTRY CANADA
MODEL I 1961

SECTOR	I CATTLE	II HOGS	III FEED GRAINS	IV FOOD GRAINS	V FORAGE CROPS	VI MEAT PROC	VII PREP FEEDS	VIII MACH & REL SV
CATTLE	0.0	0.0	0.0	0.0	0.0	0.080000	0.0	0.0
HOGS	0.0	0.0	0.0	0.0	0.0	0.010000	0.0	0.0
FEED GRAINS	0.220000	0.160000	0.0	0.0	0.0	0.0	0.110000	0.0
FOOD GRAINS	2.280000	0.630000	0.0	0.0	0.0	0.0	0.160000	0.0
FORAGE CROPS	0.0	0.220000	0.0	0.0	0.0	0.0	1.020000	0.0
MEAT PROC	12.000000	25.899994	0.0	0.0	0.0	0.0	0.190000	0.0
PREP FEEDS	0.0	0.0	0.0	0.0	0.0	235.389999	0.0	0.0
MACH & REL SV	2.419999	5.799999	0.010000	0.010000	0.010000	7.830000	7.610000	0.0

For example, a change in output by the 'hog' sector would generate 16 percent as much indirect output requirements from the 'feed grains' sector as it would direct requirements. Since direct requirements are 47 cents per dollar of output, this magnitude of the indirect to direct ratio is a potent force.

Two other ratios in Table X are worth noting. They are those between livestock production and 'machinery and related services' sectors. The magnitudes for them are as large as 2.42 between the 'cattle' sector and the 'machinery' sector, and 5.80 between the 'hogs' sector and 'machinery' sector. These results emphasize the fact that the inter-relationships existing between the sectors may be vastly understated if observations are limited to only direct transactions between them.

Structural analysis. Going back to Table V, one can examine the multiplier effects of a $1 change in final demand for output of a sector.[22] As far as the model I is concerned, a $1 change in final demand for output of the 'cattle' sector would bring forth a multiplier effect in the order of 1.69. For the 'hogs' sector, the magnitude of multiplier effect would be 2.01, much greater than that of the 'cattle' sector.

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[22]For the concept of the "output multiplier" please see page 28 and Appendix A.

A $1 increase in delivery of output of meat processing sector would have a multiplier effect of 2.32. And a $1 increase in final demand for output of prepared feeds would bring about 1.46 of multiplier effect.

A more aggregate model was also used for this purpose. In Table XI interdependence coefficients were computed for the model which enables us to see the inter-relationships between primary and secondary agriculture, and between agricultural and other sectors of the economy, in terms of changes in the final bill of goods and services.

TABLE XI

INTERDEPENDENCE COEFFICIENTS, LIVESTOCK INDUSTRY CANADA, MODEL II, 1961

Sector	I	II	III	IV
I Secondary Agriculture	1.101830	-	0.519105	-
II Primary Agriculture	0.494818	1.076122	0.299661	-
III Meats and Feeds	0.112898	-	1.206985	-
IV Machinery & Rel.Services	0.175639	0.290871	0.113858	1.011721

One dollar's worth of output of secondary agriculture delivered to final demand sectors would require inputs from primary agriculture to the extent of about 50 cents. Inputs from the 'meats and feeds' sector cost 11 cents, and from the 'machinery and related services' sector, 18 cents. A dollar

worth of products delivered from the 'meats and feeds' sector to the final demand sectors were associated with 52 cents worth of output from secondary agriculture and with 30 cents of output from primary agriculture. These relationships point out the current situation with respect to the farmer's share of the consumer's dollar. It is evident that the farmer's share of the consumer's dollar was relatively less in crop production than in livestock production in 1961.

Further analysis of structural interdependency between sectors can be seen in Table XII. It reveals that a 10 percent change in final demand for outputs of secondary and primary agriculture had quite a small effect on the 'meats and feeds' industries and 'machinery and related services' sector. Relative changes in output requirements for these sectors were 0.31 percent and 0.21 percent, respectively. Nevertheless, a 10 percent change in final demand for products of the 'meats and feeds' sector did have greater effects on agricultural sectors, 6.23 percent on secondary agriculture and 2.67 percent on primary agriculture.

TABLE XII

STRUCTURAL INTERDEPENDENCY BETWEEN FOUR AGGREGATE SECTORS, 1961

1961 Output $'000	1961 Final Demand $000	Percent change in output resulting from a 10% change in final demand for.			
		Secondary Agriculture	Primary Agriculture	Meats and Feeds	Machinery & Related Services
1,027,915	393,470	4.22	-	6.23	-
1,384,817	822,796	1.41	6.39	2.67	-
1,429,597	1,233,508	0.31	-	10.41	-
3,264,087	2,802,783	0.21	0.73	0.43	8.69

Intertemporal comparisons. Production of input-output coefficients at different points in time can be used to predict changes in productivity coefficients and interdependence of sectors. To allow an analysis of this nature, census years, 1961, 1951, and 1941 were selected to study the interdependence and input-output coefficients of the sectors concerned in both Model I and Model II. Data for 1951 and 1941, comparable to the 1961 data given in Table III were collected and formulated into input-output flow tables in terms of 1951 constant dollars.

The original data for the three years were adjusted to the 1951 price level by use of the price indexes for each sector. The adjusted flows for the three years are given in

Table XIII. From the adjusted input-output flow tables, the technical production or input coefficients, in terms of 1951 dollars, were calculated as shown in Table XIV in the same manner as for Table IV of 1961. Table XV was then derived from Table XIV.

The flows in Table XIII and the input coefficients in Table XIV allow us to measure changes in the structural production relationships over time. While beef production has steadily increased the hog production has remained at relatively the same level during the past two decades. This is because the price elasticity of demand was higher and income elasticity of demand lower for pork than for beef. Due to the drought experienced in Prairie Provinces in 1961 total production of both food and feed grains decreased to the level of 1941. Around five hundred millions of dollars' worth of feed grains was produced in 1961 and $550 millions worth of food grains for the same year. Production of other sectors associated with livestock industry all doubled over the years except the 'forage crops' sector.

Use of forage crops in cattle production has largely been expanded since 1941. The rate of increase in consumption of these crops was much greater than that of cattle production. While $92,341,000 worth of these crops was fed in 1941, $258,734,000 was fed in 1961. Similarly, prepared feeds consumed by cattle have increased from $6,467,000 to

TABLE XIII

TRANSACTION TABLE LIVESTOCK INDUSTRY CANADA 1941 1951 & 1961
MODEL I IN 1951 DOLLARS
THOUSAND DOLLARS AT PRODUCERS' PRICES

SECTOR	YEAR	I CATTLE	II HOGS	III FEED GRAINS	IV FOOD GRAINS	V FORAGE CROPS	VI MEAT PROC	VII PREP FEEDS	VIII MACH & REL SV	IX_a UNALLOCATED	X_a EXPORTS	X_b IMPORTS	XI INV CHANGE	GOVER
	1941	21556	0	0	0	0	247094	0	0	94296	41144	-278	31484	
I	1951	46747	0	0	0	0	327074	0	0	119575	58859	-991	28311	
	1961	60524	0	0	0	0	406363	0	0	119040	103580	-1565	38585	
	1941	0	1144	0	0	0	265411	0	0	80387	1522	0	8519	
II	1951	0	863	0	0	0	239242	0	0	99317	225	0	31897	
	1961	0	2145	0	0	0	272360	0	0	77441	1285	0	4754	
	1941	19169	172726	48496	0	0	0	67357	0	218032	7289	-12425	-33517	
III	1951	29263	194948	83839	0	0	0	46682	0	182455	129612	-16527	94086	
	1961	48245	189449	37825	0	0	0	64792	0	51739	49079	-41153	103804	
	1941	1259	26802	0	50758	0	0	4171	0	148464	291946	0	-140241	
IV	1951	1044	9397	0	58283	0	0	15119	0	194557	483455	-109	126646	
	1961	1196	11980	0	74115	0	0	23591	0	172485	630532	-13	269689	
	1941	92341	3672	0	0	0	0	216	0	305759	515	-4	0	
V	1951	193526	3744	0	0	0	0	716	0	268954	1675	-318	0	
	1961	258734	3013	0	0	0	0	1566	0	313728	1474	-1740	0	
	1941	0	0	0	0	0	55632	3526	0	76798	238718	-91833	0	
VI	1951	0	0	0	0	0	83628	8256	0	38944	82080	-117949	13790	
	1961	143	143	0	0	0	241052	14761	0	4199	86882	-115338	3388	
	1941	6467	37755	0	0	0	156	336	0	86341	3139	-287	0	
VII	1951	20790	63171	0	0	0	207	583	0	120370	4613	-284	919	
	1961	34485	77481	0	0	0	313	1044	0	239889	2346	-413	402	
	1941	10177	9917	65779	52028	42007	2145	737	25245	431265	0	0	0	12
VIII	1951	16928	8560	112305	97322	67053	6490	1801	46826	616692	0	0	66910	
	1961	25411	9486	110770	130819	103213	11881	3099	35240	538862	0	0	12661	1
	1941	289885	112393	390221	418058	351096	283503	53627	1118984	0	2438969	-3110156	0	30
IX_b	1951	263459	98931	532514	728087	392144	192685	128196	1682452	0	2777370	-4263072	0	46
	1961	370402	70157	342689	344392	466330	513175	246939	2638598	0	4479868	-6480852	0	90
	1941	18038	23112	16159	4885	9395	44840	5844	294335	5684481	0	0	0	14
$XIII_b$	1951	26400	176000	157000	47000	9100	65374	14313	368605	8492208	0	0	0	12
	1961	21852	108300	124960	37170	7241	77161	15708	368182	9700564	0	0	0	23
	1941	458892	387521	520655	525729	402498	898781	135814	1438564	0	3023242	-3214983	181593	46
GDI	1951	598157	3972147	744358	888392	468297	914700	215666	2097883	0	3537889	-4399250	914000	59
	1961	830993	374684	503780	553043	576784	1522305	371500	3042020	0	5355046	-6641074	30886	114

TABLE XIII

LE LIVESTOCK INDUSTRY CANADA 1941 1951 & 1961
MODEL I IN 1951 DOLLARS
THOUSAND DOLLARS AT PRODUCERS' PRICES

GRAINS	IV FOOD GRAINS	V FORAGE CROPS	VI MEAT PROC	VII PREP FEEDS	VIII MACH & REL SV	IX_a UNALLOCATED	X_a EXPORTS	X_b IMPORTS	XI INV CHANGE	XII GOVERNMENT	$XIII_a$ CONSUMPTION	GROSS DOMESTIC OUTPUT
0	0	0	247094	0	0	94296	41144	-278	31484	0	23596	458892
0	0	0	327074	0	0	119575	58859	-991	28311	0	18582	598157
0	0	0	406363	0	0	119040	103580	-1565	38585	0	24467	830994
0	0	0	265411	0	0	80387	1522	0	8519	0	30540	387523
0	0	0	239242	0	0	99317	225	0	31897	0	25670	397214
0	0	0	272360	0	0	77441	1285	0	4754	0	16699	374684
8496	0	0	0	67357	0	218032	7289	-12425	-33517	0	10	520655
3839	0	0	0	46682	0	182455	129612	-16527	94086	0	0	744358
7825	0	0	0	64792	0	51739	49079	-41153	103804	0	0	503780
0	50758	0	0	4171	0	148464	291946	0	-140241	0	2329	525729
0	58283	0	0	15119	0	194557	483455	-109	126646	0	0	888392
0	74115	0	0	23591	0	172485	630532	-13	269689	0	0	553043
0	0	0	0	216	0	305759	515	-4	0	0	0	4024980
0	0	0	0	716	0	268954	1675	-318	0	0	0	468297
0	0	0	0	1566	0	313728	1474	-1740	0	0	0	576784
0	0	0	55632	3526	0	76798	238718	-91833	0	35542	580398	898781
0	0	0	83628	8256	0	38944	82080	-117949	13790	0	805952	914700
0	0	0	241052	14761	0	4199	86882	-115338	3388	0	1287075	1522305
0	0	0	156	336	0	86341	3139	-287	0	0	19070	1358140
0	0	0	207	583	0	120370	4613	-284	919	0	5297	215666
0	0	0	313	1044	0	239889	2346	-413	402	0	15953	371500
779	52028	42007	2145	737	25245	431265	0	0	0	1270720	6721920	14385640
305	97322	67053	6490	1801	46826	616692	0	0	66910	52000	1005000	2097887
770	130819	103213	11881	3099	35240	538862	0	0	12661	104380	1956198	3042020
221	418058	351096	283503	53627	1118984	0	2438969	-3110156	0	3054083	10492328	0
514	728087	392144	192685	128196	1682452	0	2777370	-4263072	0	4627001	3645499	0
689	344392	466330	513175	246939	2638598	0	4479868	-6480852	0	9019466	25494688	0
159	4885	9395	44840	5844	294335	5684481	0	0	0	1403608	270575	7504697
000	47000	9100	65374	14313	368605	8492208	0	0	0	1290000	318000	10304000
960	37170	7241	77161	15708	368182	9700564	0	0	0	2303108	569689	12520987
655	525729	402498	898781	135814	1438564	0	3023242	-3214983	181593	4620305	12073875	0
358	888392	468297	914700	215666	2097883	0	3537889	-4399250	914000	5969000	15824000	0
780	553043	576784	1522305	371500	3042020	0	5355046	-6641074	30886	11426954	29364769	0

$34,485,000 in the same period. During the years 1941 and 1961, food grains had been increasingly substituted for by feed grains in beef production. As shown in Table XIV, for $1 worth of cattle output, 4 cents, 5 cents and 6 cents were required of feed grains in 1941, 1951 and 1961, respectively. On the other hand, requirements for food grains decreased from 0.3 cents, 0.2 cents to 0.1 cents per $1 worth of cattle output. The same trend happened in pork production. The direct requirement of feed grains increased from 44 cents per $1 worth of output in 1941 to 50 cents per $1 worth of output in 1961, whereas the direct requirement for food grains per $1 worth output declined from 7 cents in 1941 to 3 cents in 1961. Use of prepared feeds has increased greatly since 1941, most of the increase has been in hog production rather than in cattle production. In 1941 only 10 cents worth of prepared feeds was required by $1 worth of hog production, while 21 cents was required in 1961. Requirements of this input in cattle production was 1 cent per $1 worth of output in 1941 and 4 cents per $1 worth of output in 1961.

Expenditure per dollar output incurred on machinery and related services has generally increased in almost all agricultural sectors because of mechanization. Technological change occurring in this respect did have great impact on labor efficiency in these sectors. Production in the fields of hogs and forage crops, for example, required 6 cents and 2 cents

TABLE XIV

INPUT-OUTPUT COEFFICIENTS LIVESTOCK INDUSTRY CANADA 1941 1951 & 1961
MODEL I IN 1951 DOLLARS

SECTOR	YEAR	I CATTLE	II HOGS	III FEED GRAINS	IV FOOD GRAINS	V FORAGE CROPS	VI MEAT PROC	VII PREP FEEDS	VIII MACH & REL SV
	1941	0.046974	0.0	0.0	0.0	0.0	0.274921	0.0	0.0
I	1951	0.078152	0.0	0.0	0.0	0.0	0.357575	0.0	0.0
	1961	0.072833	0.0	0.0	0.0	0.0	0.266939	0.0	0.0
	1941	0.0	0.002952	0.0	0.0	0.0	0.295301	0.0	0.0
II	1951	0.0	0.002173	0.0	0.0	0.0	0.261552	0.0	0.0
	1961	0.0	0.005725	0.0	0.0	0.0	0.178913	0.0	0.0
	1941	0.041772	0.445720	0.093144	0.0	0.0	0.0	0.495950	0.0
III	1951	0.048922	0.490788	0.112633	0.0	0.0	0.0	0.216455	0.0
	1961	0.058057	0.505623	0.075082	0.0	0.0	0.0	0.174406	0.0
	1941	0.002744	0.069163	0.0	0.096548	0.0	0.0	0.030711	0.0
IV	1951	0.001745	0.023657	0.0	0.065605	0.0	0.0	0.070104	0.0
	1961	0.001439	0.031974	0.0	0.134013	0.0	0.0	0.063502	0.0
	1941	0.201226	0.009476	0.0	0.0	0.0	0.0	0.001590	0.0
V	1951	0.323537	0.009426	0.0	0.0	0.0	0.0	0.003320	0.0
	1961	0.311355	0.008041	0.0	0.0	0.0	0.0	0.004215	0.0
	1941	0.0	0.0	0.0	0.0	0.0	0.061897	0.025962	0.0
VI	1951	0.0	0.0	0.0	0.0	0.0	0.091427	0.038281	0.0
	1961	0.000172	0.000382	0.0	0.0	0.0	0.158347	0.039734	0.0
	1941	0.014093	0.097427	0.0	0.0	0.0	0.000174	0.002474	0.0
VII	1951	0.034757	0.159035	0.0	0.0	0.0	0.000226	0.002703	0.0
	1961	0.041499	0.206790	0.0	0.0	0.0	0.000206	0.002810	0.0
	1941	0.022177	0.025591	0.126339	0.098964	0.104366	0.002387	0.005427	0.017549
VIII	1951	0.028300	0.021550	0.150875	0.109548	0.143185	0.007095	0.008351	0.022321
	1961	0.030579	0.025317	0.219878	0.236544	0.178946	0.007805	0.008342	0.011584
	1941	0.039308	0.059641	0.031036	0.009292	0.023342	0.049890	0.043029	0.204603
LABOR	1951	0.044136	0.044309	0.021092	0.005290	0.019432	0.071470	0.066367	0.175703
	1961	0.026296	0.028904	0.024804	0.006721	0.012554	0.050687	0.042283	0.121032

worth of labor per $1 worth of output in 1941 whereas only 3 cents and 1 cent worth of labor were required for each $1 worth of output in the rest of sectors also declined since 1941 as indicated in the last row of Table XIV.

The interdependence between both secondary and primary agriculture and the machinery sector has been increasing. Output requirements for 'machinery and related services' sector generated by $1 worth of Cattle delivered to final demand sectors increased from 5 cents in 1941 to 11 cents in 1961. In the case of hog production, the requirements increased from 11 cents to 17 cents. Mechanization in hog production has been heavier than that in cattle production over the years despite that direct requirement of machinery and related services in cattle production has been slightly. One dollar's worth of feed grains delivered to final demand required 14 cents worth of mechanization in 1941 and 24 cents in 1961. For 'food grains' sector, a $1 worth of output delivered to final demand was associated with 11 cents and 27 cents worth of machinery and related services in 1941 and in 1961.

Aggregate technical changes. Observing aggregate technical change over time through input-output analysis requires a "backward projection" of the outputs. This procedure is used for Table XVI. In constructing this table, Model II was adopted. First of all, an input-output table for the three years were compiled from Model I in Table XIII.

TABLE XV

INTERDEPENDENCE COEFFICIENTS LIVESTOCK INDUSTRY CANADA 1941 1951 & 1961
MODEL I IN 1951 DOLLARS

SECTOR	YEAR	I CATTLE	II HOGS	III FEED GRAINS	IV FOOD GRAINS	V FORAGE CROPS	VI MEAT PROC	VII PREP FEEDS	VIII MACH & REL SV
	1941	1.049406	0.000783	0.0	0.0	0.0	0.307788	0.008011	0.0
I	1951	1.085396	0.002618	0.0	0.0	0.0	0.427923	0.016426	0.0
	1961	1.079228	0.002974	0.0	0.0	0.0	0.342924	0.013664	0.0
	1941	0.000122	1.003762	0.0	0.0	0.0	0.316007	0.008225	0.0
II	1951	0.000419	1.003945	0.0	0.0	0.0	0.289175	0.011100	0.0
	1961	0.000422	1.007614	0.0	0.0	0.0	0.214328	0.008540	0.0
	1941	0.056513	0.547008	1.102711	0.0	0.0	0.188854	0.553161	0.0
III	1951	0.069315	0.594485	1.126928	0.0	0.0	0.198477	0.252209	0.0
	1961	0.076459	0.590443	1.081177	0.0	0.0	0.149810	0.195064	0.0
	1941	0.003701	0.080177	0.0	1.106865	0.0	0.026330	0.034763	0.0
IV	1951	0.004881	0.037441	0.0	1.070210	0.0	0.012718	0.075717	0.0
	1961	0.005109	0.052540	0.0	1.154752	0.0	0.012807	0.074046	0.0
	1941	0.211193	0.009825	0.0	0.0	1.000000	0.064986	0.003285	0.0
V	1951	0.351296	0.010842	0.0	0.0	1.000000	0.141378	0.008756	0.0
	1961	0.336217	0.009909	0.0	0.0	1.000000	0.108743	0.008560	0.0
	1941	0.000411	0.002713	0.0	0.0	0.0	1.066959	0.027769	0.0
VI	1951	0.001597	0.006749	0.0	0.0	0.0	1.103209	0.042346	0.0
	1961	0.002345	0.010328	0.0	0.0	0.0	1.191089	0.047460	0.0
	1941	0.014838	0.098048	0.0	0.0	0.0	0.035398	1.003401	0.0
VII	1951	0.037894	0.160188	0.0	0.0	0.0	0.061277	1.005060	0.0
	1961	0.045001	0.209078	0.0	0.0	0.0	0.058963	1.005165	0.0
	1941	0.053850	0.106175	0.141804	0.111496	0.106230	0.051808	0.080990	1.017861
VIII	1951	0.094454	0.121146	0.173907	0.119916	0.146454	0.080049	0.058299	1.022829
	1961	0.112899	0.173461	0.240513	0.276351	0.181043	0.082080	0.072163	1.011720

And then an interdependence coefficients table for the three years were calculated from it. With these coefficients available it is possible now to set up Table XVI by projecting 1941 and 1951 outputs on the basis of 1941 and 1951 final bill of goods and sets of 1951 and 1961 coefficients.

TABLE XVI

PROJECTION OF THE GROSS OUTPUTS FOR 1941 AND 1951 FROM INTERDEPENDENCE COEFFICIENTS FOR 1951 AND 1961 (Thousand Dollars)

Sector	1941 Adjusted Gross Output	Projected 1941 Gross Output	1951 Gross Output	Projected 1951 Gross Output
Secondary Agriculture	846,415	959,140	995,371	1,057,356
Primary Agriculture	1,448,882	1,562,664	2,101,047	2,142,103
Meats and Feeds	1,034,595	1,201,143	1,130,366	1,354,316
Machinery & Related Services ..	1,438,564	1,503,236	2,097,887	2,258,172

Based on the comparisons of original actual outputs with projected outputs, one set for each year, 1941 and 1951, it is apparent that aggregate technical changes occurred in every sector over the period 1941 and 1951. The projected output of each sector is greater than its original

actual output. For the period 1951-1961, it seems that technical changes occurred in all sectors except in 'primary agriculture' sector. The magnitude of projected 1951 output for the sector is $2,142,103,000 which is very close to original actual output, $2,101,047,000.

The results of backward projection for livestock production in Canada in particular, have shown that projected output for 1941 is $959,140,000 while actual output of the same year was $846,415,000; and that for 1951, while actual output was $995,371,000 the projected output is $1,057,356,000. Greater technological changes occurred between the period 1941-1951 than between the period 1951-1961.

CHAPTER VI

PROJECTED BEEF AND PORK REQUIREMENTS FOR 1975

Economic implications of input-output models for the livestock industry have been set forth in some detail in the previous chapter. The account is not intended to be exhaustive. However, some of the significant inter-industry relationships underlying the livestock industry at the national level were discussed.

Knowledge would be futile were it not used as a guide to action. The second part of this thesis is thus an attempt to apply the information obtained so far to a more penetrating analysis on the possible development of the livestock industry and the meat processing industry in Canada in general, and in the Prairie Provinces and Manitoba in particular. As it is not possible here to build an input-output model for the livestock industry on a regional and/or provincial basis, a combined application of simple regression analysis and input-output analysis was made to serve this purpose.

In the following analysis beef and pork production in the Prairie Provinces and in Manitoba will be taken up first. Trends of production will then be traced, starting with the year 1951. Extrapolations on these trends to the year 1975 are to be incorporated into a projection of beef and pork

requirements in Canada, which will be made by employing the input-output model, to give projections for the Prairie Provinces and Manitoba, respectively. The problem of inter-regional transactions of beef and pork is examined right after the projections have been made. Lastly, the impact of expansion in beef and pork production on the meat processing industry are dealt with.

Beef and pork production in the Prairie Provinces. Time series analysis in relative terms has shown that livestock production has been primarily located in both the Central and Prairie regions of the country.[23] As indicated in Table XVII, about 95 percent of beef and pork has been produced in these two regions since 1940. Livestock production in these two regions was of a competitive nature. While one expanded the other contracted. This is apparent in Figure 2. Since 1950 there has been a tendency for production in the Central region to decline in significance as compared to production in the Prairie region. It is interesting to note that the Prairie Provinces, long known as the "bread-basket" of Canada, have produced more than half of all the cattle produced in Canada since 1940.

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[23] Canada is divided into four regions in this study: viz., Maritimes, Central (including Quebec and Ontario), Prairie, and British Columbia.

TABLE XVII

LIVESTOCK MARKETINGS BY REGIONS AS A PERCENTAGE OF THE TOTAL MARKETINGS IN CANADA, 1940 - 1965

Livestock or Regions	Periods					
	1940-44	1945-49	1950-54	1955-59	1960-64	1965
	%	%	%	%	%	%
CATTLE						
Maritimes	0.87	1.03	1.67	1.43	1.39	1.48
Central	40.81	35.63	39.58	35.66	35.05	34.17
Prairie	55.14	60.51	55.78	59.88	60.96	61.44
B.C.	3.18	2.86	2.92	3.04	2.61	2.90
CALF						
Maritimes	3.36	3.53	3.62	2.78	1.72	1.41
Central	61.74	58.50	61.36	57.57	51.13	48.86
Prairie	34.27	37.33	33.97	38.51	45.70	47.91
B.C.	0.59	0.64	1.04	1.13	1.39	1.82
HOG						
Maritimes	1.47	2.18	3.35	2.15	2.64	2.94
Central	39.93	53.89	58.76	52.99	57.87	58.14
Prairie	58.20	42.89	37.15	44.27	39.00	38.40
B.C.	0.42	0.63	0.71	0.59	0.49	0.47

Source: Calculated from Livestock Market Review, Canada Department of Agriculture, Ottawa.

In the Central region, both cattle and calf production declined in the past few decades. Its share of cattle production in the period 1940-44 was 41 percent. It declined to 34 percent in 1965. Calf production decreased even more, from 62 percent in the period 1940-44 to 49 percent in 1965. On the other hand, hog production in this region increased from 40 percent to 58 percent of Canada's total in the same period. In contrast to the Central region, cattle and calf

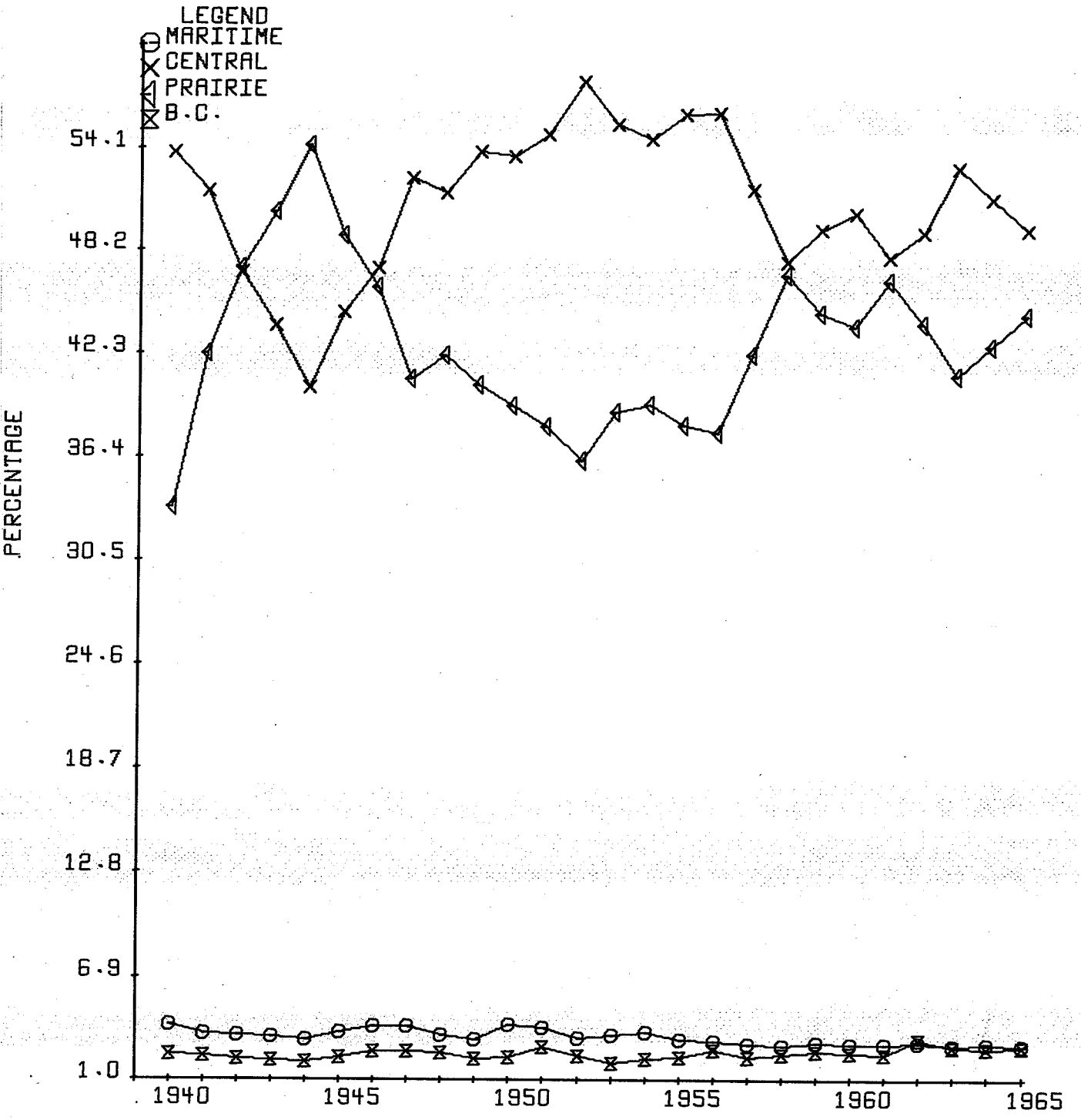

FIG. 2 CASH INCOME FROM CATTLE CALVES AND HOGS BY REGIONS AS A PERCENTAGE OF THAT OF CANADA 1940-1965

production in the Prairie region increased, but hog production decreased. The share of cattle production in the Prairie region increased from 55 percent in the 1940-44 period to 61 percent in 1965. Calf production in the same region increased from 34 percent to 48 percent whereas the percentage of hog production declined from 58 to 38 percent.

The Prairie percentage of cash income from livestock production in Canada was higher than that of the Central region during the period 1942-45. Since then, it has dropped below that of Central region. This situation was caused by hog production in the Prairie region during the same period (see Figure 4). In Figure 3 we can see that the pattern of cattle and calve production has been quite different from that of hog production in the Prairie region. There has been keen competition in cattle production between the Prairie and Central regions. For some years cattle production in Central region was greater than that in the Prairie region, for other years it lagged behind the Prairie region. It seems that cattle and calf production in Prairie Provinces will eventually dominate for the years to come.

The trend line fitted in Figure 3 for cattle and calf production in the Prairie region during the period 1951-65 appears as follows:

$$(VI - 1) \quad \hat{P}_c = 40.22 + 0.70979t$$

where $\hat{P}_c$ stands for the Prairie percentage of cash income

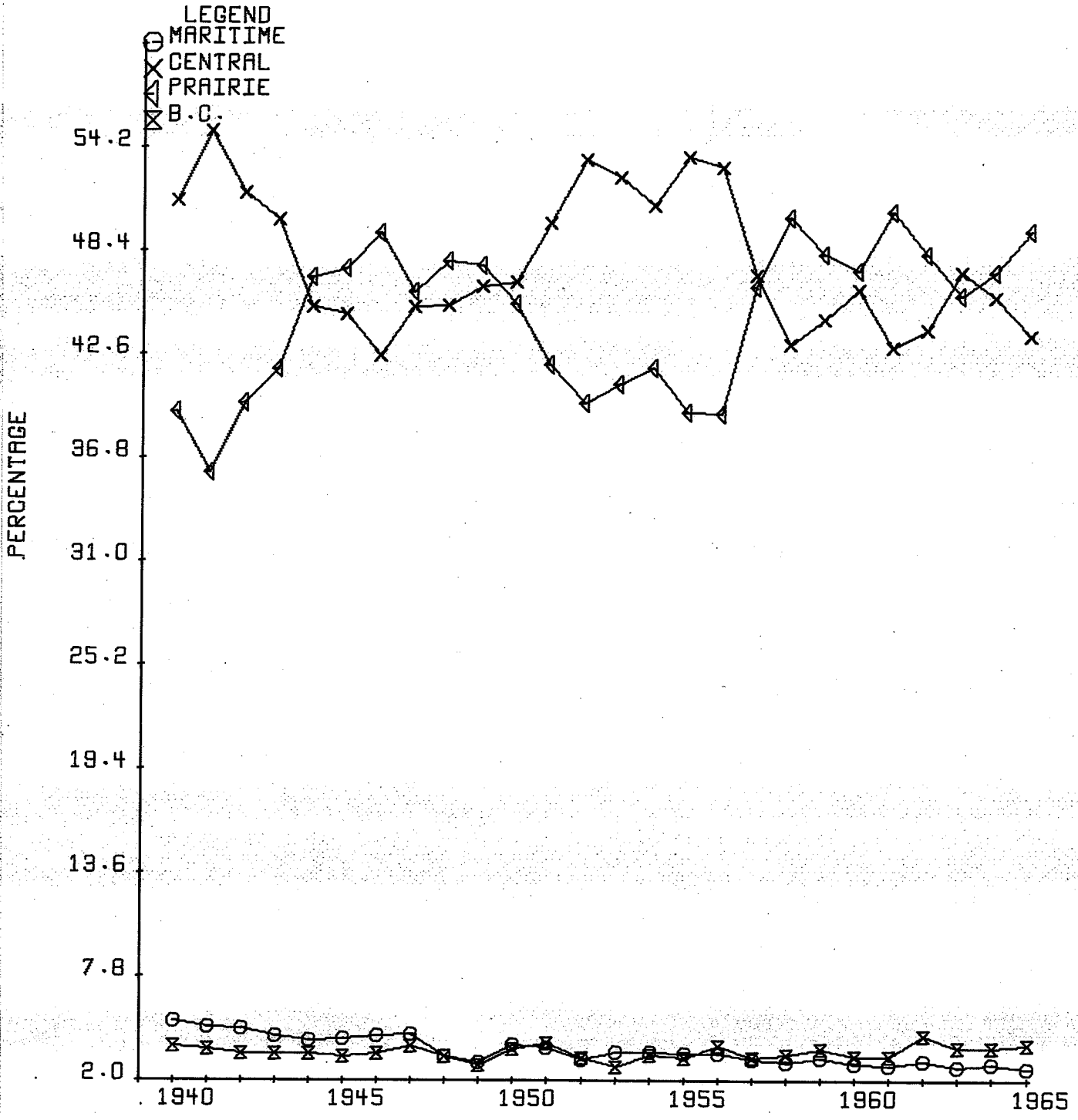

FIG. 3 CASH INCOME FROM CATTLE AND CALVES BY REGIONS AS A PERCENTAGE OF THAT OF CANADA 1940-1965

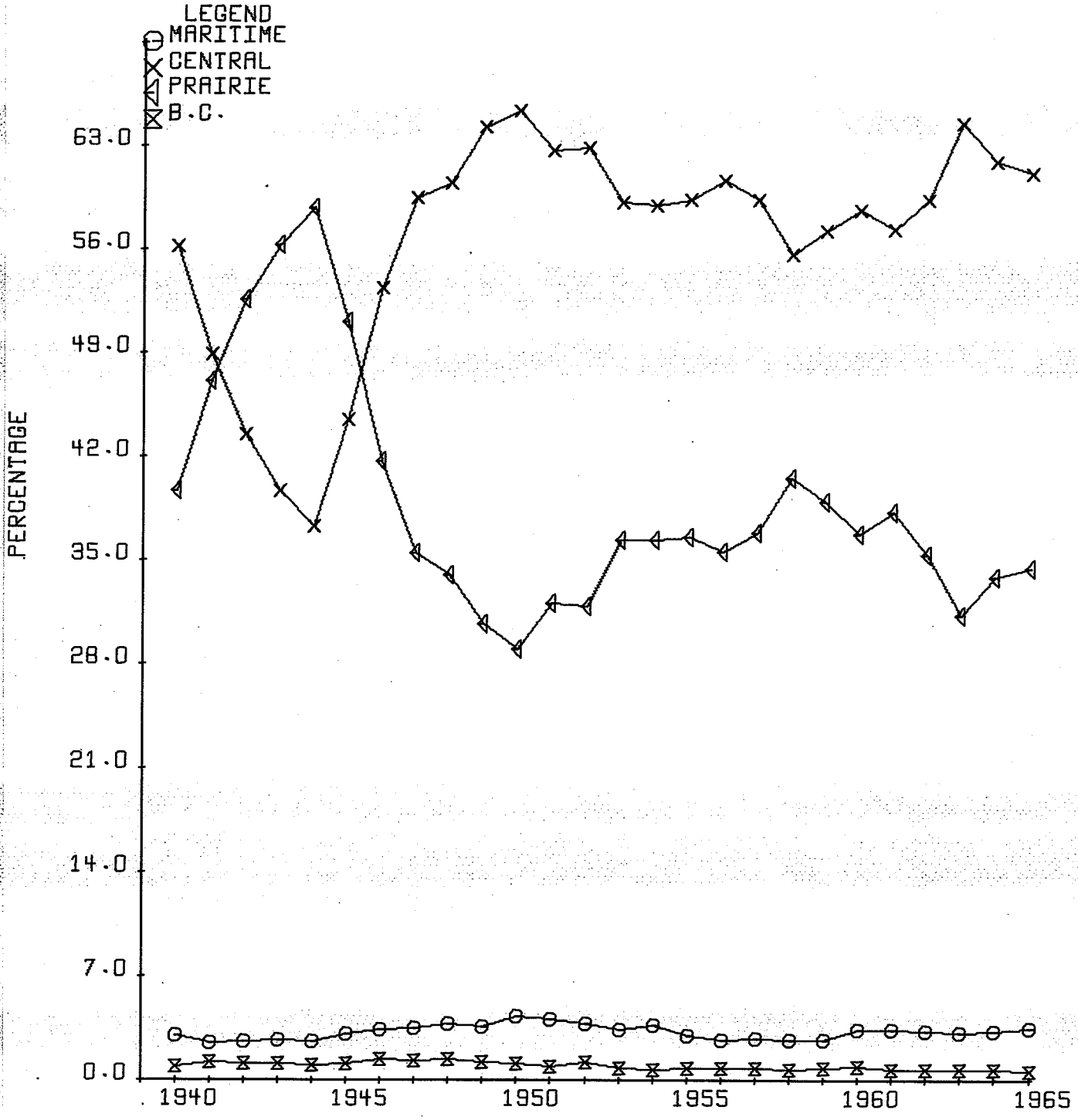

FIG. 4 CASH INCOME FROM HOGS BY REGIONS AS A PERCENTAGE OF THAT OF CANADA 1940-1965

from cattle and calf production in Canada and t stands for years (0, 1, 2, ...). The annual rate of growth was 0.71 percent.

The annual rate of growth of hog production in the Prairie region was much less than that of cattle and calf production of the region as seen in the following trend equation.

$$(VI - 2) \quad \hat{P}_h = 35.54 + 0.03071t$$

where $\hat{P}_h$ stands for the Prairie share of cash income from hog production in Canada. The increase per annum was as small as 0.03 percent during the past 15 years.

Beef and pork production in Manitoba. Within the Prairie region, Alberta has had the largest share of livestock production. The next has been Saskatchewan. Manitoba has produced the smallest share of beef and pork (see Figure 5). While the share of livestock production in Manitoba remained quite constant in the past the shares of Alberta and Saskatchewan fluctuated greatly. Both changed in a similar pace.

Of the increase of the Prairie percentage of cattle production in Canada, most was located in Alberta. The share in this province increased from 23 percent in the period 1940-44 to 32 percent in 1965. An increase of almost 10 percent was made. Actually the percentage shares of Manitoba and Saskatchewan decreased from 12 to 10 and from 20 to 19, respectively. The increase in the share of calf production was the highest in Saskatchewan. It was 10 percent in the

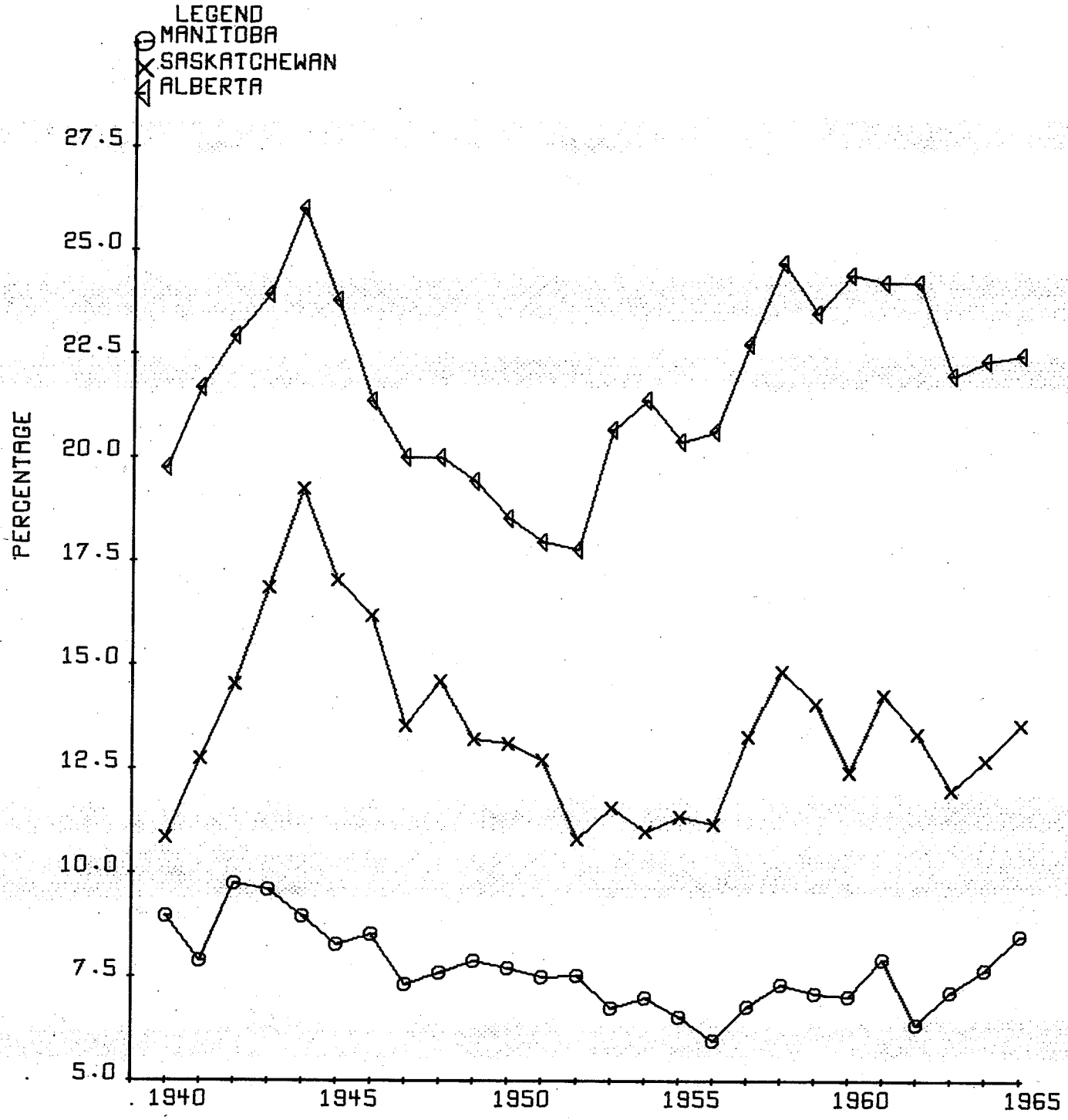

FIG. 5 CASH INCOME FROM CATTLE CALVES AND HOGS IN PRAIRIE PROVINCES AS A PERCENTAGE OF THAT OF CANADA 1940-1965

period 1940-44. By 1965 it increased to 18 percent. There was also an increase of the share of calf production in Alberta. The change was from 12 percent in the period 1940-44 to 18 percent in 1965. The difference between the two provinces was that the increase in the latter had been steady whereas in the former unsteady. The share of calf production in Manitoba remained quite constant, around 11 percent, during the same period.

Alberta and Saskatchewan were also most responsible for the decrease in the share of hog production in the Prairie region. It appears that while hog production remained at a constant level the expansion in livestock production in Alberta was made in cattle and calves. The percentage share of hog production decreased from 32 in the period 1940-44 to 23 in 1965. In Saskatchewan, while there was only expansion of the share of calf production, the share of hog production declined from 17 percent to 7 percent in the past twenty-five years.

During the 1940's cattle and calf production in Saskatchewan was competitive with that in Alberta. However, although the same rate of increase in calf production has existed in both provinces, a sharp increase in cattle production in Alberta has reduced Saskatchewan's competitive position. The share of cash income from cattle and calves in Manitoba has declined since 1940. Although there was

TABLE XVIII

LIVESTOCK MARKETINGS BY PROVINCES AS A PERCENTAGE OF THE TOTAL MARKETINGS IN CANADA, 1940 - 1965

Livestock or Provinces	Periods					
	1940-44	1945-49	1950-54	1955-59	1960-64	1965
	%	%	%	%	%	%
CATTLE						
P.E.I.	0.42	0.45	0.72	0.67	0.61	0.56
N.S.	0.15	0.18	0.34	0.29	0.43	0.43
N.B.	0.30	0.40	0.61	0.47	0.35	0.49
Que.	5.63	5.23	5.97	4.95	4.43	4.48
Ont.	35.18	30.40	33.61	30.71	30.62	29.69
Man.	12.29	10.71	9.70	9.16	9.48	10.00
Sask.	20.09	23.41	19.81	20.41	18.94	19.41
Alta.	22.76	26.39	26.27	30.31	32.54	32.03
B.C.	3.18	2.86	2.92	3.04	2.61	2.90
CALF						
P.E.I.	0.72	0.76	0.29	0.34	0.20	0.17
N.S.	0.35	0.33	0.47	0.56	0.51	0.46
N.B.	2.30	2.44	2.86	1.88	1.01	0.78
Que.	27.04	28.26	32.42	31.60	28.94	26.66
Ont.	34.70	30.24	28.94	25.97	22.19	22.20
Man.	12.05	11.19	9.57	9.24	9.21	11.94
Sask.	10.18	12.55	10.39	12.62	16.94	18.13
Alta.	12.04	13.59	14.01	16.65	19.55	17.84
B.C.	0.59	0.64	1.04	1.13	1.39	1.82
HOG						
P.E.I.	0.86	1.42	1.75	1.23	1.21	1.37
N.S.	0.15	0.28	0.52	0.32	0.81	1.11
N.B.	0.46	0.88	1.08	0.60	0.62	0.46
Que.	7.49	14.31	19.81	17.61	20.15	20.94
Ont.	32.44	39.58	38.95	35.38	37.72	37.20
Man.	9.52	6.82	6.22	6.97	7.46	8.17
Sask.	16.54	10.11	7.44	10.12	7.69	7.14
Alta.	32.14	25.96	23.49	27.18	23.85	23.09
B.C.	0.42	0.63	0.71	0.59	0.49	0.47

Source: Calculated from Livestock Market Review, Canada Department of Agriculture.

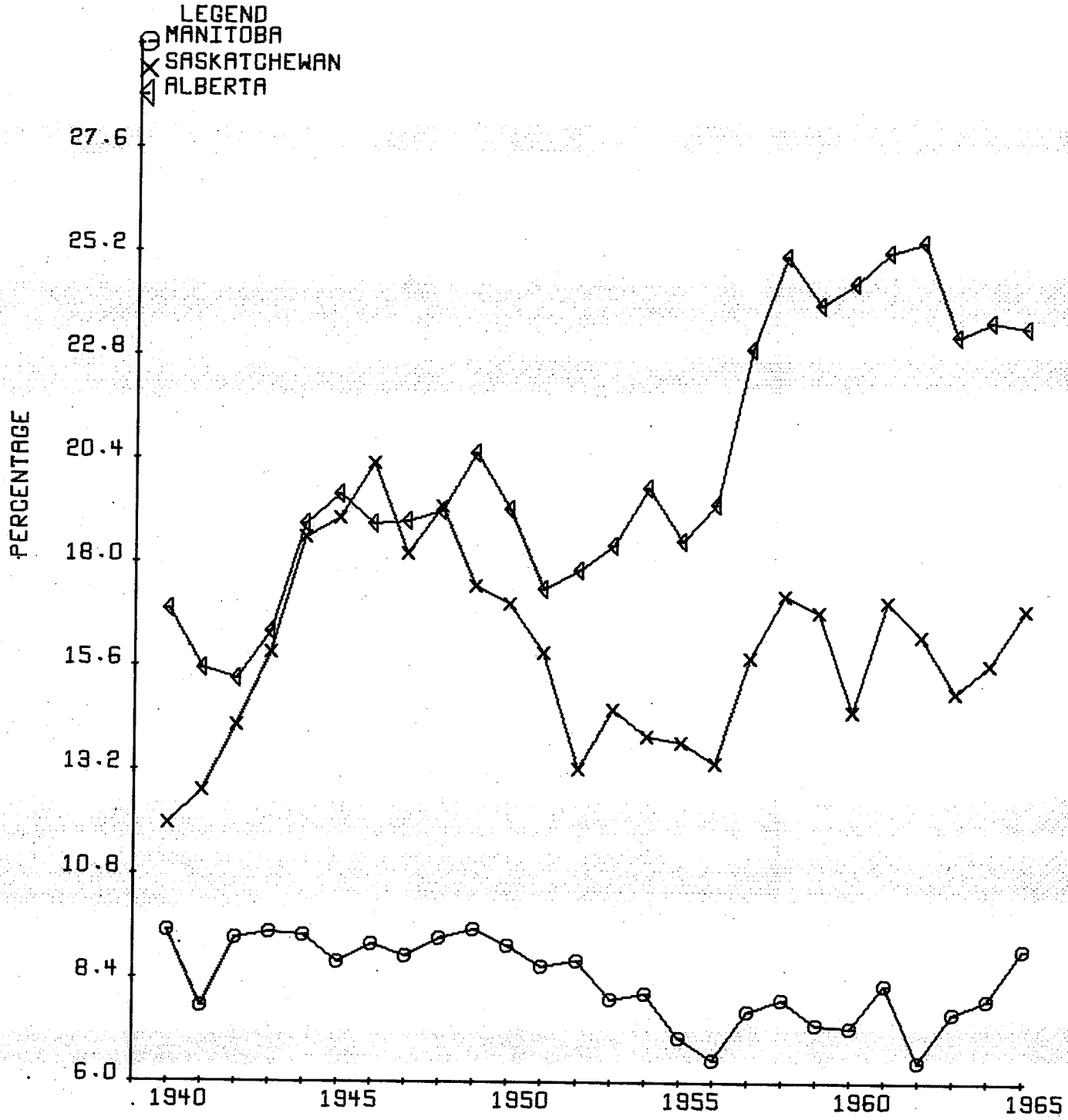

FIG. 6 CASH INCOME FROM CATTLE AND CALVES IN PRAIRIE PROVINCES AS A PERCENTAGE OF THAT OF CANADA 1940-1965

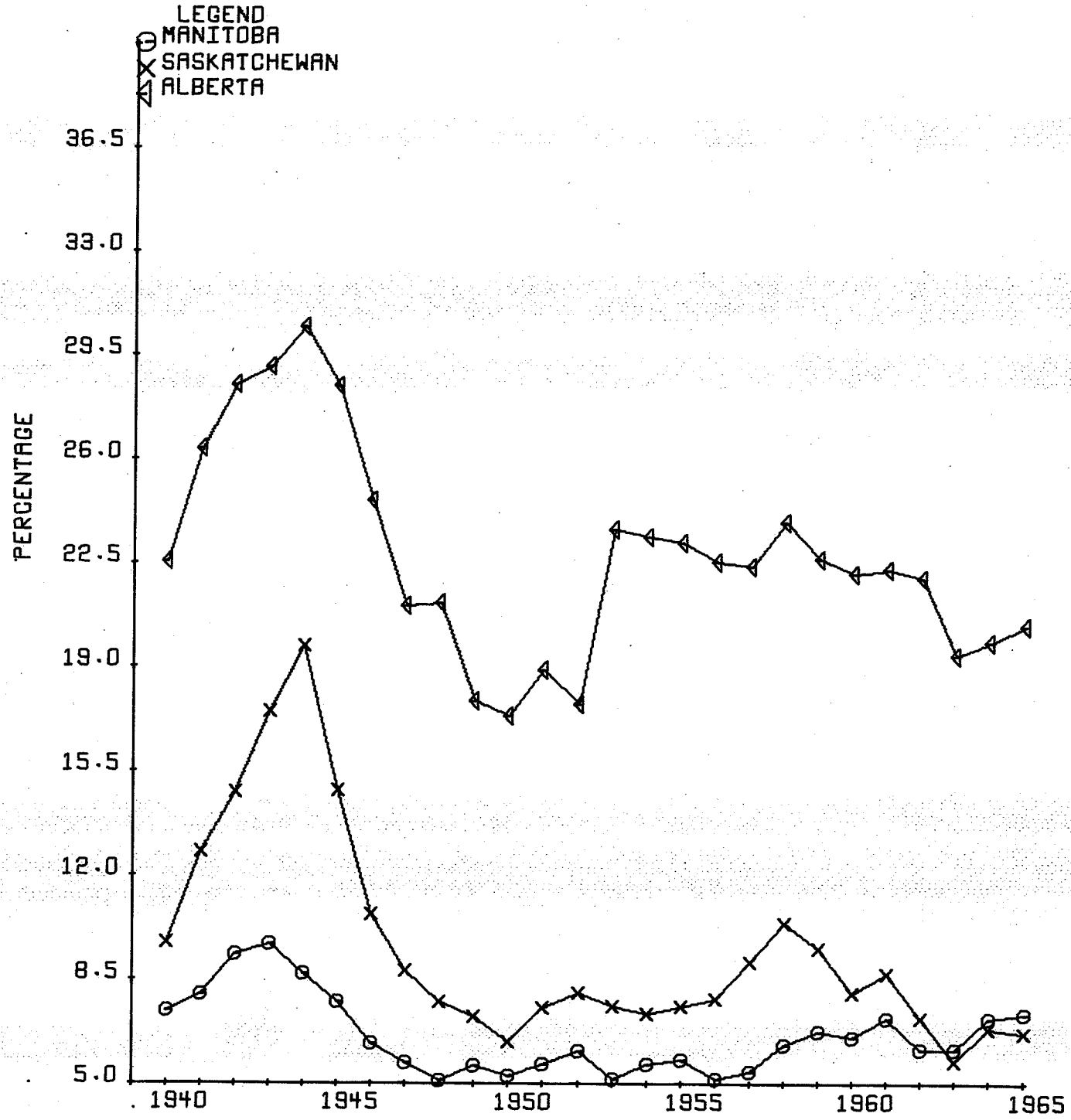

FIG. 7 CASH INCOME FROM HOGS IN PRAIRIE PROVINCES AS A PERCENTAGE OF THAT OF CANADA 1940-1965

small increase in recent years it has not recovered to the previous level. The trend line fitted to Figure 6 has shown that there was tendency for the share of cash income from cattle and calves in Manitoba to decrease.

$$(VI - 3) \quad \hat{M}_c = 7.92 - 0.02014t$$

where $\hat{M}_c$ stands for cash income from cattle and calves in Manitoba as a percentage of that of Canada. The annual rate of decrease was 0.02 percent since 1951.

Changes in the share of cash income from hogs in three Prairie Provinces have followed the same pattern since 1940 as shown in Figure 7, although there was a greater fluctuation in Alberta. The share of Saskatchewan has declined to the level of Manitoba in recent years. Contrary to both Alberta and Saskatchewan, Manitoba has shown a slight increase in the share of cash income from hog production since 1951. The rate of increase per annum was 0.12 percent as indicated in the following trend equation:

$$(VI - 4) \quad \hat{M}_h = 5.34 + 0.12132t$$

where $\hat{M}_h$ stands for cash income from hogs in Manitoba as a percentage of that of Canada as a whole.

Economic situation in the next ten years. The foregoing is the past trends of beef and pork production in the Prairie region in general and in Manitoba in particular. Under certain assumptions, it can also provide a reasonable basis for projection to the near future. Hence it will be

of assistance to what is to be done in the next section - projection of beef and pork requirements in 1975. Extrapolation of regression trends was applied both to beef and pork production in the Prairie region and in Manitoba, and to the meat processing industry in Manitoba in this study. A projection of output of the meat processing industry is to be employed in analyzing the impact of expansion in meat consumption on the level of employment in that industry.

The method of extrapolation is briefly described as follows: least-square regression equations (VI - 1 to VI - 4) were employed. Since the year 1951 was denoted as t = 0, t - value for the year 1975 is 24. By simply substituting this value into the equations we obtain the projected percentages for 1975.

Thus, projected cash income from cattle and beef production in the Prairie region as a percentage of that of Canada is 57.25 percent (Equation VI - 1). The projected share of hog production in the Prairie region is 36.28 percent (Equation VI - 2). For Manitoba, the projected cash income from cattle and calves as a percentage of that of Canada is 7.44 percent (Equation VI - 3); that from hogs is 8.25 percent (Equation VI - 4). The trend equation fitted to the data on total production of the meat processing industry in Manitoba as a percentage of that of Canada as shown in Table XXII is,

$$(VI - 5) \quad \hat{M}_m = 13.77 - 0.23439t$$

where $\hat{M}_m$ stands for Manitoba's share in meat processing.

Therefore, the projected share of meat processing in Manitoba is approximately 8 percent in 1975.

To complete the information necessary for projection of beef and pork requirements by 1975, one more thing is to be done. As mentioned in Chapter III, data on the final bill of goods has to be obtained either from the projection made by other studies, or by one's own. For the purpose of this study, the component in the final bill of goods to be projected is consumption of red meat in Canada by 1975. Fortunately, there have been some studies[24] made in this respect and the figures contained therein can be adapted.

As shown in Table XIX consumption of red meat in Canada by 1975 has been predicted to increase more than twice the volume consumed in the period 1950-54. Consumption of beef and veal would increase from 954 million pounds in 1950-54 to 2,198 million pounds in 1975. The increase of pork consumption would be from 762 million pounds to 1,525 million pounds; and that of lamb and mutton, from 33 million pounds to 86 million pounds in the same time interval. Using 1961 as a base year, there would be a 57.6 percent increase in consumption of beef and veal by 1975. The increase of pork consumption would be 67.6 percent. The percentage change in consumption of lamb and mutton would by 32.30. The percent-

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[24]Department of Agricultural Economics, University of Manitoba, Development of the Livestock Industry, etc., July, 1962; M. Menzies, and F. Shefrin. "Demand Outlook for Canadian Agriculture", in Resources for Tomorrow, July, 1961.

ages along with the consumption of each kind of red meat in 1961 measured in value terms were then combined to obtain a weighted percentage of increase in total red meat consumption. It turned out to be approximately 61 percent. The household consumption of red meat in 1961 was valued at $953,207,829. Adding a 61 percent increase to this value, the projected household demand for red meat in Canada by 1975 appears to be in the amount of $1,534,665,000. The final bill of goods to be employed to project output requirements of beef and pork by 1975 in the next section contains this value and the sum of values which represents the consumption of red meat by exogenous sectors other than household in Table III.

TABLE XIX

CONSUMPTION OF RED MEAT IN CANADA
1950-61 AND PROJECTION TO 1975
(Million Pounds)

Items	Period					Change from 1961 to 1975 (%)
	Ave. 1950-54	Ave. 1955-59	1960	1961	1975	
Beef & Veal	954	1,284	1,368	1,395	2,198	57.56
Pork	762	845	983	910	1,525	67.58
Lamb & Mutton	33	45	57	65	86	32.30

Source: Department of Agricultural Economics, University of Manitoba., Development of the Livestock Industry, etc., July, 1962; DBS 23-203, Livestock and Animal Products Statistics, 1965.

Projected beef and pork requirements in Canada for 1975. Input-output models have been used for projecting output in future time periods. The current model is used for projection of output requirements of beef and pork in 1975, based on derived structures in 1961. In order to make the results of the present analysis comparable to those obtained in the study conducted in the Department of Agricultural Economics, University of Manitoba not many years ago, all comparisons in this section were made on the basis of 1960 conditions.

The results presented in Table XX indicate that cattle production in Canada by 1975 must increase by 53.4 percent over the 1960 level to meet projected final demand for products of the meat processing industry. This includes an absolute increase in the amount of $328,642,000 at 1961 constant dollars. If this is realized total production of beef and veal in the Prairie region would increase from $266,866,000 in 1960 to $540,309,000 in 1975, an absolute increase of $273,443,000. That is to say, an 83.2 percent increase over the 1960 level would result. among the three provinces in the Prairie region, 7.4 percent of $540,309,000, or $66,064,000 worth of beef and veal would be produced in Manitoba(see last section). Compared to the 1960 level of beef production in Manitoba this would be an increase of 61.3 percent.

To meet the same projected final demand for meats in 1975, hog production in Canada is required to increase from $297,767,000 in 1960 to $516,418,000. Although this increase in production is smaller in absolute terms than that in cattle production ($218,651,000 as compared to $328,642,000), it is greater in relative terms (73.43 percent as compared to 53.4 percent). The regression trend has indicated that 36.3 percent of the total production in Canada would be located in the Prairie region, amounting to $206,567,000 in 1961 dollars. This represents a 59.4 percent increase over 1960 level of production, an absolute increase of $104,354,000. Hog production in Manitoba would be more than doubled by then. The percentage increase over the production in 1960 is projected to be 126.7 an absolute increase of $23,087,000.

Considering internal requirements as well as inter-industry demand for meat products, total output requirement of the meat processing industry must increase 70.5 percent over the 1961 level if an expansion of 61 percent in final demand for their products is to be met by 1975. In the vicinity of 10 percent increase in total production is required by intra and inter-industry demands.

TABLE XX

PROJECTED BEEF AND PORK REQUIREMENTS IN CANADA
1960 - 1975, Thousands of Dollars

Items		Canada	Prairie	Manitoba
Cattle	1960	615,129	266,866	40,960
	1975	943,771	540,309	66,064
	Abso. Inc.	328,642	273,443	25,104
	% Inc.	53.42	83.20	61.28
Hogs	1960	297,767	102,213	18,226
	1975	516,418	206,567	41,313
	Abso. Inc.	218,651	104,354	23,087
	% Inc.	73.43	59.43	126.67
Meat Processing	1961	1,127,419		
	1975	1,921,745		
	Abso. Inc.	794,326	*	*
	% Inc.	70.46		

* Not relevant to the problems in hand.

In view of the increase of beef and pork production projected above, a question as to market outlets arises. Will the increase of beef and pork production in the Prairie region and in Manitoba be entirely absorbed locally, or will most of the meat products be shipped out of the region and the province? What would be the impact of this expansion in demand for meat products on the level of employment in the

meat processing industry in Manitoba? Important questions such as these will be answered in the next two sections.

Interregional transactions of beef and pork. It was estimated that 1.3 billion pounds of beef and pork, or 45 percent of the total production in Canada, would be moved from the Prairie Provinces to the deficit areas in British Columbia and Eastern Canada by 1975; and that approximately 60 percent of the beef and pork produced in Manitoba would be exported to Eastern Canada and to some degree to the U.S.A., if Manitoba producers succeed in doubling the production over the next 10 years.[25]

Examination of Table XXI reveals that there has been only a small percentage of live animals shipped from the Prairie Provinces to British Columbia and Eastern Canada since 1951. Shipments of cattle and calves from the Prairie Provinces to these deficit areas remained relatively unchanged in the past decade and half, while that of hogs declined from 5.0 percent of total shipments of Canada as a whole in 1951 to 2.5 percent in 1965. Cattle and calves shipped from the Prairie region to British Columbia and Eastern Canada were only 2.6 percent and 1.6 percent of total shipments in Canada in 1965. Compared to total shipments in the Prairie region

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[25] Department of Agricultural Economics, University of Manitoba, op. cit.

itself, only 4.1 percent of cattle, 3.6 percent of calves, and 6.6 percent of hogs were shipped to the two deficit areas.

Among the three Prairie Provinces, shipments of cattle from Manitoba and Alberta to British Columbia and Eastern Canada declined in proportion to their total shipments. This was more so in the case of Manitoba. In 1951, 14.3 percent of total shipment of cattle in Manitoba was shipped to these two deficit areas, whereas the percentage dropped to 4.7 in 1965. Shipment of calves from Manitoba has shown a similar trend, while that from Alberta increased slightly. Both cattle and calf shipments from Saskatchewan to British Columbia and Eastern Canada had little change in proportion to its total shipment during the past 15 years. Manitoba shipped a very small percentage of its hogs to the two deficit areas in the past. The shipment in 1965 was really negligible, only 0.03 percent. The shipment of hogs from Saskatchewan has been similar to that from Manitoba. Most of the shipments of hogs from the Prairie region to the two deficit areas, especially to British Columbia, was originated in Alberta. Shipments from Alberta have also declined relatively. In 1951 it was 25.3 percent of its total shipment; only 10.8 percent was shipped in 1965.

On the basis of past trends just examined, it is unlikely that shipments of live animals from the Prairie Provinces to British Columbia and Eastern Canada will increase

TABLE XXI

PRAIRIE PERCENTAGE OF LIVESTOCK SHIPMENTS
TO BRITISH COLUMBIA AND EASTERN CANADA
1951 - 1965*

	Prairie as of Canada Total Shipment	Prairie as of Prairie Total Shipment	Manitoba as of Manitoba Total Shipment	Saskatchewan as of Saskatchewan Total Shipment	Alberta as of Alberta Total Shipment
	%	%	%	%	%
CATTLE					
1951	3.82	6.77	14.31	5.78	4.11
1952	4.23	7.49	14.33	5.69	5.71
1953	5.02	8.38	15.52	7.04	6.33
1954	4.37	7.30	11.67	7.32	5.60
1955	4.12	7.07	14.01	7.03	4.59
1956	4.62	7.69	14.31	7.87	5.40
1957	3.57	5.68	8.86	5.79	4.49
1958	2.44	4.01	2.05	4.86	4.13
1959	2.39	3.87	4.54	4.82	3.04
1960	2.50	4.00	3.90	4.65	3.67
1961	2.18	3.36	4.59	4.67	2.06
1962	1.52	2.55	4.05	5.21	0.69
1963	1.87	3.13	3.97	6.48	1.16
1964	2.37	3.87	6.84	7.13	1.17
1965	2.56	4.10	4.66	6.09	2.83
CALVES					
1951	1.64	4.87	10.54	4.35	0.89
1952	2.18	6.73	12.76	7.98	0.68
1953	2.81	8.09	14.08	8.38	2.69
1954	2.56	7.23	10.85	7.49	4.27
1955	1.76	5.32	9.31	6.27	1.86
1956	2.25	6.50	10.56	7.96	2.70
1957	0.80	2.09	3.82	2.94	0.52
1958	0.33	0.77	0.89	1.47	0.19
1959	1.63	3.90	5.78	6.16	0.84
1960	1.31	3.34	4.80	4.98	1.15
1961	1.57	3.29	6.47	3.35	1.18
1962	0.88	1.98	3.60	3.00	0.34
1963	1.19	2.95	5.62	4.07	0.47
1964	2.75	6.50	9.55	9.18	2.32
1965	1.63	3.60	5.32	4.14	1.56

* See next page.

TABLE XXI (continued)

	Prairie as of Canada Total Shipment	Prairie as of Prairie Total Shipment	Manitoba as of Manitoba Total Shipment	Saskatchewan as of Saskatchewan Total Shipment	Alberta as of Alberta Total Shipment
	%	%	%	%	%
HOGS					
1951	5.04	15.63	1.13	0.17	25.34
1952	4.27	12.18	0.59	0.07	20.79
1953	6.41	14.76	1.20	0.63	21.95
1954	6.43	14.71	1.28	0.94	21.76
1955	6.36	14.02	0.64	0.47	21.99
1956	5.72	13.45	0.50	0.28	21.47
1957	5.41	12.70	0.96	0.30	20.06
1958	5.87	12.72	1.12	0.42	20.48
1959	5.50	12.31	0.62	0.35	20.48
1960	5.24	12.33	0.47	0.99	19.62
1961	4.55	10.61	0.74	0.56	17.25
1962	3.49	8.68	0.42	0.36	13.53
1963	2.65	8.00	0.08	0.21	12.70
1964	2.09	5.76	-	0.15	9.75
1965	2.52	6.56	0.03	0.08	10.87

Source: Livestock Marketing Review, Canada Department of Agriculture, Ottawa.

* Excluding Newfoundland.

proportionately by 1975. But it is conceivable that there would be a large increase in the output of the meat processing industry in these provinces as a large increase in livestock production in these provinces was projected in the last section of this study, and a great portion of output of this industry would flow to British Columbia, Eastern Canada, and United States.

Total and direct labor requirements in meat processing industry by 1975. According to the data published by the Dominion Bureau of Statistics, most of the meat processing plants are located in the Central region. It is seen in Figure 8 that in 1964, more than half of the products of the meat slaughtering and packing plants was produced in Ontario and Quebec. About 80 percent of the products of sausage and sausage casing manufacturers in Canada was made in these two provinces. Ontario has been the principal province in manufacturing products of animal oils and fats.

Total production of the meat processing industry in Canada was valued at $770,522,000 in 1950, of which 13.7 percent was produced in Manitoba. Fifteen years later, although the absolute value of production in Manitoba has increased, it has not increased as rapid as Canada's total production. The share of total production in Manitoba was about 4 percent smaller. As calculated in the trend equation (VI - 5) the rate of decrease in proportion was 0.23 percent per annum.

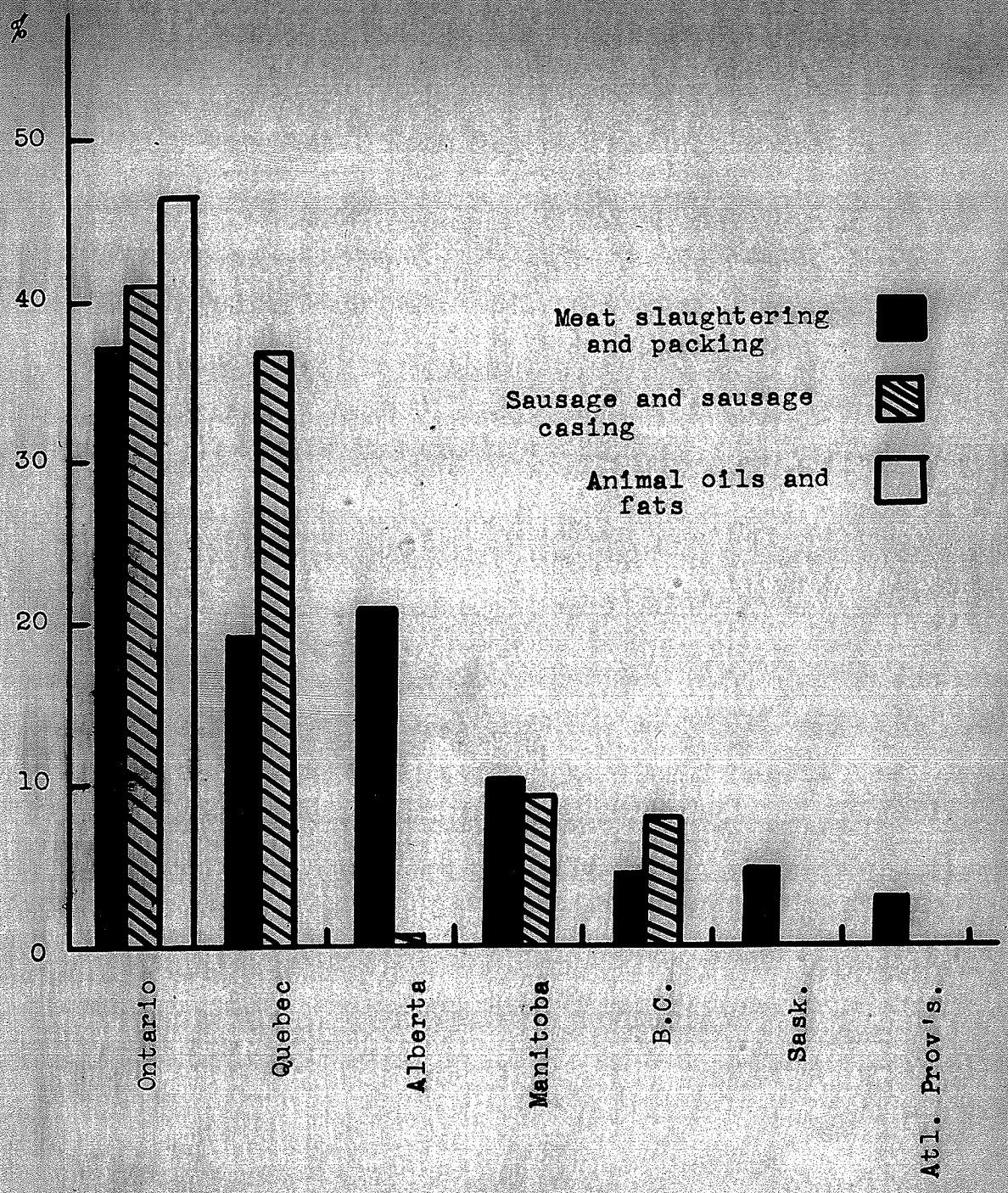

FIGURE 8

GEOGRAPHICAL DISTRIBUTION OF MEAT PROCESSING INDUSTRY IN CANADA, 1964, IN TERMS OF TOTAL SHIPMENTS OF PRODUCTS (FROM DBS, 32-221, SLAUGHTERING AND MEAT PROCESSORS, 1964)

TABLE XXII

TOTAL PRODUCTION AND LABOR REQUIREMENT OF MEAT PROCESSING INDUSTRY IN MANITOBA AND CANADA AS A WHOLE, 1950 - 1964

Year	Total Production*			Labor Requirements	
	Canada	Manitoba**		Canada	Manitoba
	$'000	$'000	%	No.	No.
1950	770,522	105,590	13.70	21,423	2,963
1951	910,131	120,692	13.26	21,927	2,860
1952	881,183	114,234	12.96	23,990	3,078
1953	848,960	112,204	13.22	24,254	3,210
1954	860,668	116,339	13.52	24,377	3,251
1955	836,228	101,835	12.18	25,152	3,233
1956	875,022	104,676	11.96	26,445	3,368
1957	941,040	113,746	12.09	26,972	3,220
1958	1,082,577	132,450	12.23	27,330	3,394
1959	1,167,192	148,443	12.72	28,441	3,444
1960+	1,091,858	124,879	11.44	27,219	3,075
1961	1,115,047	128,737	11.55	20,972	2,365
1962	1,180,734	125,612	10.64	20,105	2,099
1963	1,197,629	121,533	10.15	20,485	2,037
1964	1,257,257	129,441	10.30	20,929	2,144

Source: DBS, 32-221 Slaughtering and Meat Processors.

* Includes products of slaughtering and meat packing and sausage and sausage casing manufacturers only.

** Manitoba has produced negligible amount of oils and fats.

\+ Data were based on Revised Industrial Classification and new establishment concept since 1961.

Also shown in Table XXII, total production in the meat processing industry has increased over the past 15 years, whereas the level of employment in the industry has not changed proportionately. This was especially so in Manitoba plants. The number of workers employed in the industry was 21,423 for Canada as a whole in 1950. In accordance with the Revised Industrial Classification and new establishment concept, the level of employment in the industry totaled 20,929 in 1964. For Manitoba, 3,075 workers were employed in the industry in 1960, only a slight increase over the employment in 1950 (about 100 workers).

Based on the output projection for the meat processing industry in Canada in 1975, $205,244,297 value of employment would be required, representing a 70 percent increase over that of 1961. In line with this and the regression estimate on the share of total production in Canada (8 percent), there would be an increase of $2,512,304 in the value of employment in Manitoba plants by 1975. Taking a $4,000 - $5,000 average wage range, as a common denominator, the interval of increase in the number of workers would be 500 - 600 as indicated in Table XXIII. This is the total employment requirement of the meat processing industry in Manitoba, if the projected output expansion by 1975 is to be realized. Direct labor requirement ($a_{oi}\ A_{ij}F_j$, in Chapter III) by that time would be in the order of $204,123,123 in 1961 constant dollars for Canada as a whole. Thus, the indirect labor requirement would amount to $1,121,174.

TABLE XXIII

PROJECTED TOTAL AND DIRECT LABOR REQUIREMENTS IN MEAT PROCESSING INDUSTRY, 1975

Items		Canada	Manitoba
Gross Domestic Product ($'000)	1961	1,127,419	130,217
	1975	1,921,745	153,740
Labor Coefficient (a_{06})		0.106801	0.106801
Labor Input ($'000)	1961	120,409	13,907
	1975	205,244	16,420
Absolute Increase ($'000)		84,835	2,513
% Increase		70.46	18.07
Average Wages and Salaries ($)	1961	4,442	4,680
	1964	4,877	5,000
No. of Additional Employees Required in 1975.	Average Wages and Salaries $4,000	21,209	628
	Average Wages and Salaries $5,000	16,967	503
Direct Labor Requirement in 1975 ($'000)		204,123	-

CHAPTER VII

LIMITATIONS OF THE FINDINGS

It has been often said, "Half knowledge is more dangerous than no knowledge", or in another expression, "Theoretically it may be all right but not practically". This is so because people are apt to forget the limitation or limitations of their knowledge and/or theory about certain things. Even the most exact sciences of today, such as the physical sciences, can be mistaken either because of human error or because of the complexity of Nature. Nor can we make something that holds true for dogs also necessarily true of cats. An appropriate attitude toward 'knowledge' and/or 'theory', therefore, seems to be that one knows the limitation or limitations of it and makes the best use accordingly.

In general, the models applied in this study do have certain limitations. Hence the findings derived therefrom must be interpreted with caution. This chapter is set out to deal with these limitations and to examine how they affect the reliability of the results.

Assumption of linearity. This assumption was made both in the regression model and in the Leontief input-output model used in this study. In theory, there is no need for one to make such an assumption. While the linearity assumption in input-output analysis is solely a practical necessity,

linear trends cast for livestock production in the Prairie region and in Manitoba for the last 15 years are based on empirical data. As changes in production processes are relatively slow in both the livestock industry and the meat processing industry, it is believed that the results made from extrapolation of these trends to 1975 are quite reliable.

Some comments on use of this assumption in Leontief input-output model have already been made in Chapter II. Assumptions of linearity of production are not new to research in agricultural production. They have been classical tools in farm management and other research. Constant returns to scale have been assumed in the commonly used technique of imputing returns to factors of production. Budgeting, employed by many agricultural economists in determining an optimum combination of farm resources, is based on the assumption of linear production relationships.

However, one of the most serious limitations of linear assumptions in input-output analysis is this: when change in the level of net output in a sector is assumed, it must also be assumed that resources to produce the net output are available and can be drawn into the sector. This is generally unrealistic in primary agriculture (and partly so in secondary agriculture) where the quantity of land is fixed and capital is not always available to the individual

producer. Limitations in this respect can have only a slight effect on the findings, since (1) projected output requirements for beef and pork by 1975 are not too large, (2) interest rates have been reasonably low in recent years, and (3) problem of land supply is relatively manageable within the range of projected output requirements.

The aggregation problem. Two types of aggregation are feasible for agricultural sectors: (1) classification by commodities and (2) classification by enterprises. The commodity basis is used in this study because of the form of available data. Independent of data limitations, both classification schemes have disadvantages.

The main objection to an enterprise classification is that output composition varies to an extent that coefficients are not uniquely defined. For example, beef farmers produce both cash and feed crops. Also, cash crop farmers raise a certain amount of livestock in addition to crops. The proportions within each farm vary over time depending on relevant price relationships and individual preferences.

Commodity groupings also have disadvantages: large numbers of agricultural commodities are joint products. The distribution of inputs among commodity groups is difficult and sometimes arbitrary. There is no established basis for allocating inputs such as machinery, building depreciation, petroleum products, etc., among individual commodities.

Structure of model. The flow model and the classification of inputs used in this study represent only one alternative which might be used. Additional study may be needed which use other models. Limitations may exist for the classification procedures used in this study.

For example, it can be questioned whether 'unallocated output' should be included as one of exogenous sectors. A more detailed model could be adopted which treats other inputs as separate intermediate sectors instead of relegating them to the residual 'unallocated' sector. Additional cost items of livestock production which can be treated as separate 'intermediate' or 'primary' sector are chemicals, construction, finance, insurance, and real estate, etc. But it is legitimate to include all other industries which are not relevant to the present study in the 'unallocated' sector.

Lack of Data. Data and time limitations must always be recognized but are not peculiar to input-output analysis. Although limitations exist, if results presented herein are interpreted with caution they provide additional quantitative information on the structural interdependence of the livestock industry in Canada as well as basis for the output projection for 1975.

Accuracy of individual entries and dependence on indirect estimating procedures are serious with respect to this limitation. Since no true figures are available for

some entries, only by examining the estimating techniques and underlying assumptions, both implicit and explicit, can one attempt to judge the reliability of the estimated data. This applies especially to the allocation of inputs among agricultural sectors.

Lack of data also prevents detailed classification of a model. Many input items could be treated as separated sectors were data required available. Imports had to be allocated to the sectors which produce similar products in this study because of lack of data on imports by sectors which use them. The disadvantage of doing this is that domestic production is not separated from foreign production as required by application of results to guide policies affecting domestic production. Data on feeder animals were confined to those marketed through public stockyards. According to the flow table compiled by Timothy Josling of the University of Guelph, 193 million dollars worth of feeder cattle and 54.6 million dollars worth of feeder hogs were internally transacted in 1958.

Ceteris paribus assumption. Probably, this would be the most serious limitation in making projection for the future. Model I of 1961 was used to project output requirements for cattle and hogs, and meat processing industries in Canada. These projections may have strict limitations because of the income elasticities of demand which attach to

agricultural products and because of changing technical coefficients and factor substitution. In addition, final demand for sectors other than the meat processing industry are assumed fixed at the 1961 level. Consequently, estimated increases for each sector reflect only changes required to meet projected demand in the 'meat processing' sector.

Other components of final demand for meat products other than household consumption are those of 'exports', 'inventory' and 'unallocated' sectors. Exports of beef and pork are not expected to be large in the near future as mentioned in Chapter I. The magnitudes of inventory and the unallocated are quite small. Therefore, it can be safely assumed that these factors would not significantly affect the reliability of the results. Final demand for other sectors in the near future may be so large that they would have significant effects on the reliability of the projections. The most important of the final demand for these sectors are exports of feed and food grains. As the supply of these agricultural products appear to be ample it seems that they too would not bring a serious bias in our findings.

Effects of changes in income elasticity, technical coefficients and factor substitution on our results may or may not be serious. It all depends on the size of changes. If it is not too radical, the effects would be tolerable.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

A structural model of the livestock economy in Canada in 1961 was first formulated using the input-output technique. Modifications and extension of this basic model were then developed as needed to satisfy the objectives of this study - to quantify and analyze the interaction of relevant economic sectors and to project output requirements for the beef, pork and meat processing industry by 1975. An analysis of structural changes over time for the years 1961, 1951 and 1941 was also conducted. In making projections for the Prairie region and Manitoba, a simple regression model was incorporated.

As evidenced in Chapter V aggregate technical changes did occur in livestock production during the past two decades. It was found that greater technological changes occurred between the period 1941 - 1951 than between the period 1951 - 1961. With respect to primary agriculture (crop production), it was observed that while technical changes occurred in the period 1941 - 1951, very little change occurred in the period 1951 - 1961.

About 95 percent of beef and pork has been produced in the Central and Prairie regions since 1940. Livestock production in these two regions was of a competitive nature,

while one expanded the other contracted. From 1950 there has been a trend for production in the Central region to decline in significance as compared to production in the Prairie region. In contrast to the Central region, cattle and calf production in the Prairie region increased, but hog production in the region decreased since 1940. The annual rate of growth of cattle and calf production in the Prairie region was 0.71 percent in terms of Canada's total. There was a slight increase in hog production in the Prairie region in the last 15 years. A trend line fitted from 1951 shows a rate of increase of 0.03 percent per annum as compared to Canada's total production.

Within the Prairie region, Manitoba has produced the smallest share of beef and pork. The share of cash income from cattle and calves in Manitoba has declined since 1940. Although there was a small increase in recent years it has not recovered to the previous level. The trend line drawn from 1951 indicates that the annual rate of decrease was 0.02 percent. On the other hand, the share of cash income from hog production has shown a slight increase since 1951. The rate of increase per annum was 0.12 percent of Canada's total.

It is estimated that total beef production in Canada by 1975 will increase by approximately 53 percent over that produced in 1960. Of the beef cattle increase in Canada

over the next 10 years, it is expected that about 83 percent of this increase will originate in the Prairie Provinces. There will be a 61 percent increase in beef production in Manitoba over that of 1960.

If the anticipated demand for pork by 1975 is to be satisfied it is estimated that hog production in Canada will have to increase by approximately 73 percent between the years 1960 and 1975. Of the increase, it is estimated that approximately 59 percent will be produced in the Prairie Provinces. Manitoba hog producers will probably more than double their production between 1960 and 1975.

Only an examination of shipments of live animals from the Prairie Provinces to British Columbia and Eastern Canada has been made in this study. On the basis of past trends, it was observed that the shipments of live animals from the Prairie Provinces to these deficit areas are unlikely to increase in proportion by 1975. But it is conceivable that there would be a large increase in output from the meat processing industry in these provinces, and that a great portion of the output of this industry would flow to British Columbia, Eastern Canada and the United States.

In line with the output projection, the meat processing industry in Canada would require $205,244,297 value of employment by 1975. This represents a 70 percent increase over that of 1961. For Manitoba plants it is estimated that

an increase of $2,512,304 worth of employment would be realized by 1975. If the level of salaries and wages in recent years is used as a common denominator, the corresponding increase would require in the vicinity also of 500 to 600 workers. These employment estimates were also made under the assumption that constant technology prevails in the industry during the next 10 years.

Findings with respect to the situation of the livestock industry and other related industries are not summarized here. They are readily followed in Chapter V. Although assumptions and problems mentioned in the immediate preceeding chapter have limited the accuracy of the results of this thesis, the input-output technique does enable us to learn many facts about our economy and make them quantitatively clear. Inter-industry analysis is needed in a range of empirical problems for which the techniques of national income analysis and of partial equilibrium analysis are inadequate.

In so far as we are able to solve the segregation problem and sufficient data are available for the sectors concerned, there is no reason why input-output analysis cannot be applied to a particular industry or economy such as livestock at the national level. It is quite certain that the results of this study can be improved if: (1) more adequate and precise data were available, and (2) some significant changes in the future were foreseen and incorporated into the model e.g., technological changes.

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A P P E N D I X E S

APPENDIX A

DEVELOPMENT OF SOME INPUT-OUTPUT MODELS

In this appendix few things concerning the development of input-output models are discussed. In addition to what has been mentioned about the concept of 'output multiplier' in Chapter III, a comparison of this concept with that of 'investment multiplier' was first made. Secondly, the derivation of Model II from Model I in input-output analysis was briefly explained. It may be appropriate that the regional and sectorial model built in the very beginning of this study be appended here. We can then compare this model with the one actually used in the thesis.

Output Multiplier[26]

The concept of 'output multiplier' is to be distinguished from that of 'investment multiplier' of Keynesian theory. The investment multiplier implies the adjustment of the economy to a general equilibrium solution of consumption, savings, and investment.

Input-output analysis does not present general equilibrium solutions as mentioned above. Each output multiplier for each sector of the economy expresses the aggregate effect on the production(excluding production of sectors not

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[26]William E. Martin and Harold O. Carter, op. cit., p. 13.

considered endogenous to the system) caused by a specified change in a particular final demand, given the technical production requirements of each industry. Because output of certain sectors is considered exogenously determined, solutions are 'partial' rather than 'complete'. For example, further consumption by households(and its multiplying effects on output) in response to increased income generated by increased production generated by an original increase in household demand is not reflected in input-output model.

Model II in Input-Output Analysis

Construction of Model I in input-output analysis has been discussed in detail in Chapter III. Model II was derived from Model I by further aggregating the intermediate sectors into four:

1. 'Primary agriculture' sector is the aggregation of 'Feed grains', 'Food grains', and 'Forage crops' sectors in Model I.

2. 'Secondary agriculture' or 'Livestock production' sector is the aggregation of 'Cattle' and 'Hogs' sectors in Model I.

3. 'Meat processing' and 'Prepared feeds' sectors were added up into one sector in Model II.

4. 'Machinery and related services' sector remains the same in Model II as in Model I.

The purpose of doing this is twofold. Model II enables

TABLE XXIV

INPUT-OUTPUT COEFFICIENTS LIVESTOCK INDUSTRY CANADA
1941 1951 & 1961 MODEL II IN 1951 DOLLARS

SECTOR	YEAR	I SEC AGRI	II PRIM AGRI	III MEAT&FEED	IV MACH & REL SV
I	1941	0.026819	0.0	0.495368	0.0
	1951	0.047831	0.0	0.501002	0.0
	1961	0.051178	0.0	0.458391	0.0
II	1941	0.373302	0.068504	0.069345	0.0
	1951	0.433931	0.067643	0.055307	0.0
	1961	0.425169	0.068523	0.047496	0.0
III	1941	0.052246	0.0	0.057655	0.0
	1951	0.084351	0.0	0.081086	0.0
	1961	0.093103	0.0	0.135795	0.0
IV	1941	0.023740	0.110302	0.002786	0.017549
	1951	0.025607	0.131687	0.007335	0.022321
	1961	0.028044	0.211068	0.007110	0.011584

TABLE XXV

INTERDEPENDENCE COEFFICIENTS LIVESTOCK INDUSTRY CANADA
1941 1951 & 1961 MODEL II IN 1951 DOLLARS

SECTOR	YEAR	I SEC AGRI	II PRIM AGRI	III MEAT&FEED	IV MACH & REL SV
I	1941	1.057398	0.0	0.555849	0.0
	1951	1.103532	0.0	0.601659	0.0
	1961	1.111803	0.0	0.589723	0.0
II	1941	0.428123	1.073542	0.304053	0.0
	1951	0.519603	1.072538	0.347846	0.0
	1961	0.513586	1.073564	0.331418	0.0
III	1941	0.058625	0.0	1.091999	0.0
	1951	0.101298	0.0	1.143470	0.0
	1961	0.119778	0.0	1.220665	0.0
IV	1941	0.073783	0.120529	0.050665	1.017861
	1951	0.099650	0.144464	0.071190	1.022829
	1961	0.142078	0.229251	0.096284	1.011720

us to analyze the interrelationships between more aggregate sectors, such as primary(crop production) and secondary(livestock production) agriculture. It also facilitates the test of technological changes in livestock production over time in aggregate terms.

Regional and Sectorial Input-Output Model

This model differs from the one used only in that in addition to classification of sectors by commodeity further seggregation are made on regional basis. Both sectors on regional basis and sectors on national basis are considered. Canada is divided into four regions, viz., the Maritime region, the Central region, the Prairie region, and B. C. region. For each region there are six sectors including, 'Cattle', 'Hogs', 'Feed grains', 'Food grains', 'Forage crops', and 'Meat processing'. 'Prepared feeds' and 'Machinery and related services' sectors along with all exogenous sectors are aggregated on national basis.

The mathematical formulation of the model is as follows: (Please see next page)

Transaction system of equations.

$$X_1^1 = x_{11}^{11} + x_{12}^{11} + \cdots + x_{16}^{11} + x_{11}^{12} + \cdots + x_{1k}^{1s} + \cdots + x_{16}^{14} + x_{17}^{1} + \cdots + Y_1^1$$

$$X_2^1 = x_{21}^{11} + x_{22}^{11} + \cdots + x_{26}^{11} + x_{21}^{12} + \cdots + x_{2k}^{1s} + \cdots + x_{26}^{14} + x_{27}^{1} + \cdots + Y_2^1$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$X_6^1 = x_{61}^{11} + x_{62}^{11} + \cdots + x_{66}^{11} + x_{61}^{12} + \cdots + x_{6k}^{1s} + \cdots + x_{66}^{14} + x_{67}^{1} + \cdots + Y_6^1$$

$$X_1^2 = x_{11}^{21} + x_{12}^{21} + \cdots + x_{16}^{21} + x_{11}^{22} + \cdots + x_{1k}^{2s} + \cdots + x_{16}^{24} + x_{17}^{2} + \cdots + Y_1^2$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

(I)
$$X_j^i = x_{j1}^{i1} + x_{j2}^{i1} + \cdots + x_{j6}^{i1} + x_{j1}^{i2} + \cdots + x_{jk}^{is} + \cdots + x_{j6}^{i4} + x_{j7}^{i} + \cdots + Y_j^i$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$X_6^4 = x_{61}^{41} + x_{62}^{41} + \cdots + x_{66}^{41} + x_{61}^{42} + \cdots + x_{6k}^{4s} + \cdots + x_{66}^{44} + x_{67}^{4} + \cdots + Y_6^4$$

$$X_7 = x_{71}^{1} + x_{72}^{1} + \cdots + x_{76}^{1} + x_{71}^{2} + \cdots + x_{7k}^{s} + \cdots + x_{76}^{4} + x_{77} + \cdots + Y_7$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$X_h = x_{h1}^{1} + x_{h2}^{1} + \cdots + x_{h6}^{1} + x_{h1}^{2} + \cdots + x_{hk}^{s} + \cdots + x_{h6}^{4} + x_{h7} + \cdots + Y_h$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$X_9 = x_{91}^{1} + x_{92}^{1} + \cdots + x_{96}^{1} + x_{91}^{2} + \cdots + x_{9k}^{s} + \cdots + x_{96}^{4} + x_{97} + \cdots + Y_9$$

or, more concisely as

(II)
$$X_j^i = \sum_{sk}\sum x_{jk}^{is} + \sum_{r} x_{jr}^{i} + Y_j^i$$

$$X_h = \sum_{sk}\sum x_{hk}^{s} + \sum_{r} x_{hr} + Y_h$$

where j,k = 1, 2, ..., 6 (which denote commodities on regional basis);

h,r = 7,8, and 9 (which denote commodities on national basis);

i,s = 1,2,3, and 4 (which stand for regions).

X_j^i = the total output of sector j in region i;

x_{jk}^{is} = the total amount of output of sector j in region i purchased by sector k in region s;

x_{jr}^i = the total amount of output of sector j in region i purchased by sectors on national basis;

..... etc.

Y_j^i = the autonomous or final demand for goods of sector j in region i;

Y_h = the autonomous or final demand for goods of sector h.

Technical input-output equations. Assuming constant production coefficients gives,

$$\text{(III)} \qquad x_{jk}^{is} = a_{jk}^{is} X_k^s \; ; \quad x_{jr}^i = a_{jr}^i X_r ; \quad x_{hk}^s = a_{hk}^s X_k^s ; \quad x_{hr} = a_{hr} X_r .$$

Substituting (III) into (II) yields in a concise form:

$$\text{(IV)} \qquad \begin{aligned} X_j^i - \sum_{sk}\sum a_{jk}^{is} X_k^s - \sum_r a_{jr}^i X_r &= Y_j^i \\ X_h - \sum_{sk}\sum a_{hk}^s X_k^s - \sum_r a_{hr} X_r &= Y_h \end{aligned}$$

Interdependence equations. Solving (IV) for the required outputs of each sector in terms of Y_j^i and Y_h gives (V):

$$\text{(V)} \qquad \begin{aligned} X_j^i &= \sum_{sk}\sum A_{jk}^{is} Y_k^s + \sum_r A_{jr}^i Y_r \\ X_h &= \sum_{sk}\sum A_{hk}^s Y_k^s + \sum_r A_{hr} Y_r \end{aligned}$$

where A's are elements in the inverse of the input coefficient matrix (IV).

On the basis of this regional and sectorial model output requirements for beef and pork in the Prairie region can be directly obtained. In addition, inter-relationships among regions and sectors can be observed, such as the evaluation of the feed freight assistance policy on the Prairie agriculture and non-agricultural sectors of the national economy.

APPENDIX B

SOURCES OF DATA

In compiling the input-output tables for livestock industry in Canada at national level, production data for agriculture as well as other sectors were in the most complete and usable form. Most of the difficulties were experienced in collecting input data for each agricultural sector. As mentioned in Chapter VII this is due to the fact that large numbers of agricultural commodities are joint products. The distribution of inputs among commodity groups is difficult. It was here that only estimated figures could be used.

Sources of data are discussed for each sector along with the composition of the sector in the following. It is not intended as a step-by-step account of all the estimating procedures, problems and data sources for each sector. In fact, in some sectors, different approaches were attempted and discarded for various reasons. Only sources of data for 1961 were discussed here. They are indicated as numbers in the parenthesis which refer to those listed in the Bibliography. Sources of data for 1941 and 1951 were almost the same as those for 1961 unless otherwise indicated.

MLl Cattle and Calves. The total output of this section is the sum of the cash income from the sale of

cattle and calves, the value of farm consumption and the value of inventory changes. In 1961 these values were $628,839,000, (17) $20,229,000 (11) and $31,902,000 (12) respectively. The value of inter-farm transactions is assumed to have been included in the cash income.

The numbers of feeder cattle and feeder calves marketed through public stockyards were obtained from (4). According to (36) 650 lbs. was approximately the average weight for feeder cattle. The average price for feeder cattle was also obtained from (4) and used to calculate the value of total transactions. The total number of cattle and calves slaughtered by 'Meat Processing Industry' sector were calculated from (18). The average farm prices obtained from DBS, Agricultural Division, and the average weights (36) were then applied to obtain total values. The value of cattle imported was derived from (30). Nine percent of the same total was added to obtain the C.I.F. value.

ML2 Hogs. To derive the total output of this sector, the same procedure used in 'cattle' sector was employed. One hundred and ten pounds was adopted as the average weight of feeder hogs (CDA, Prod. & Mktg. Branch). The average price and number of feeder hogs marketed through public stockyards were all obtained from (4). The distribution of outputs of 'hogs' sector to other sectors was obtained in the same way

as that used in 'cattle' sector.

ML3 & 4 Feed grains and food grains. The output data for these sectors were available in (4). The intra-sector transaction was estimated by using acreages and average seeding rates. Since there were no data on grains consumed by cattle and hogs, Jenning's report (4) was adapted. The procedure was to first calculate the percentages of each kind of grain consumed by cattle and hogs as of the total livestock consumption. Adjusting these percentages to the actual production of cattle and hogs in Canada, we obtained the percentages of grains fed to cattle and hogs in Canada. These percentages were applied to total grains consumed by livestock (mostly estimated by A. G. Wilson of U. of M.) to derive the amounts fed to cattle and hogs. The grains used as materials in feed industry were obtained from (19) and valued at farm prices (14). The export of food grains was greater than the amount produced in 1961. It was supposed to come entirely from year-to-year carryover. The amounts of inventory changes in each kind of grains were obtained directly from the Agricultural Division, Dominion Bureau of Statistics.

ML5 Forage crops. To derive the amount of forage crops fed to cattle and hogs, the segregation between cattle and hogs needs to be done only in the case of pas-

ture. Fodder corn and hay are feeds for cattle exclusively. The same technique of segregation employed for grains was also applied here. The total production of pasture in Canada in 1941, 1951 and 1961 was estimated by A. G. Wilson of the University of Manitoba. The data contained in Jenning's report (41) were the basis for segregation of the amount fed to cattle and the amount fed to hogs.

ML6 Meat Processing. The data on total production of this sector was available in (18). The amount of intra-sector transactions and the domestic disappearance of meats in Canada were available directly from DBS, Industry Division. The purchases of feeds industry from meat processing industry, and inventory changes were recorded in (19). It is assumed that the figures provided by DBS include farm consumption of meats. Therefore, deduction of this part was made to avoid double counting. Imports and exports of meat products were available in (30).

ML7 Prepared Feeds. Farm use of millfeeds was added to total production of feed manufacturers (19) to derive the gross domestic output of the sector. Because of lack of data, prepared feeds used in the meat processing industry were estimated by using Carter's study in Iowa (6). The input coefficient, 0.000226, was adopted. The same estimation procedure was employed to obtain the value of intra-sector

transaction. The coefficient adopted was 0.002931.

Prepared feeds consumed by cattle and hogs were estimated from data directly obtained from DBS, Agricultural Division, by using Josling's flow table (43). Adjustments with respect to changes in volumes of production through time were made. The flow of prepared feeds to 'Household Consumption' sector includes canned food, biscuit, and others for dogs and cats (19).

ML8 Machinery and Related Services. This is a rather mixed sector which consists of seven manufacturing industries, viz., Machine shop SIC 308,[27] Miscellaneous metal fabricating industries SIC 309, Agricultural implements industry SIC 311, Miscellaneous machinery and equipment manufacturers SIC 315, Motor vehicle manufacturers SIC 323, Motor vehicle parts and accessories manufacturers SIC 325, and Petroleum refiners SIC 365. The gross domestic product of this sector was obtained by summing up the factory shipment and inventory change of each component industry.

The method of procedure in estimating distribution from this sector to all sectors included in the model can be stated in three parts. First, for distribution to all agricultural sectors, total farm expenditures on the following

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[27] SIC stands for Standard Industrial Classification. Please see (9).

items were enumerated from the data contained in (17) with some minor adjustments: tractor operating expenses, combines, gasoline engines, trucks, automobiles, machinery repair parts, and depreciation on machinery. From these figures the share for livestock production was separated along with those for 'feed grains', 'food grains' and 'forage crops' sectors by applying data in (6). The results are presented in Table XXVII.

TABLE XXVI

RELATIVE HOURS OF TRACTOR, TRUCK AND AUTOMOBILE REQUIRED FOR EACH COMMODITY SECTOR CANADA, 1941, 1951 AND 1961 (Percentages)

Items	Year	Livestock	Feed Grains	Food Grains	Forage Crops
Tractor and Machinery	1941	5.36	25.92	17.83	18.97
	1951	4.37	26.07	18.44	17.38
	1961	5.55	20.95	19.50	21.69
Petroleum	1941	19.74	20.19	21.70	11.40
	1951	16.10	20.30	22.44	10.44
	1961	20.44	16.32	23.74	13.03
Trucks	1941	23.97	14.61	40.31	3.09
	1951	19.55	14.69	41.68	2.83
	1961	24.82	11.81	44.10	3.54
Automobile	1941	65.42	15.30	11.82	-
	1951	53.36	15.38	12.22	-
	1961	67.74	12.36	12.93	-

Source: Adapted from (6).

TABLE XXVII

EXPENDITURES OF AGRICULTURAL SECTORS ON MACHINERY AND RELATED SERVICES, CANADA, 1941, 1951 & 1961
(Thousands of Dollars)

	Year	Livestock	Feed Grains	Food Grains	Forage Crops	Agri-culture
	1941	6,209	30,027	20,655	21,976	115,844
Tractor and	1951	16,187	96,569	68,306	64,380	370,423
Machinery	1961	27,118	102,365	95,280	105,981	488,616
	1941	905	926	995	523	4,587
Petroleum	1951	1,824	2,300	2,543	1,183	11,331
	1961	2,768	2,210	3,215	1,764	13,542
	1941	3,405	2,075	5,726	439	14,204
Trucks	1951	13,878	10,428	29,588	2,009	70,988
	1961	28,847	13,726	51,255	4,114	116,225
	1941	19,765	4,622	3,571	-	30,213
Automobile	1951	27,815	8,017	6,370	-	52,127
	1961	43,374	7,914	8,279	-	64,030
	1941	30,284	37,650	30,947	22,938	164,848
Total	1951	59,704	117,314	106,807	67,572	504,869
	1961	102,107	126,215	158,029	111,859	614,121

Source: Adapted from (6).

Note: Figures in the Flow tables established were adjusted to producer's prices.

Figures for 'cattle' and 'hogs' sectors were further derived from the amount of distribution to livestock production. In this respect, Josling's flow table (43) was used to calculate the percentage shares of machinery and related services expenditure for 'cattle' and 'hogs' sectors as that of total livestock production. The percentages thus obtained were adjusted to relative change in productions of 'cattle' and 'hogs' sectors between 1958 and 1961.

Secondly, for 'meat processing' sector 'prepared feeds' sector and 'machinery' sector itself, only repair expenditure on machinery and equipment, and fuel used were taken into account. The data on repair expenditure and fuel consumed are available in (18), (19), and DBS publications on each machinery industry concerned.

Distributions of products of 'machinery' sector to 'government' and 'household' sectors were obtained from (31) and (32). Items included in household consumption were fuel, gas, automobiles, and automotive operating expenses.

ML9 'Unallocated' Sector. The unallocated output of each intermediate sector was calculated as residual. This was done by subtracting all figures in a row (except negative inventory change) from the sum of gross domestic output and import. The unallocated input of each column was determined by deducting all figures in the column from gross domestic inputs of the same sector.

ML10 Exports and Imports. The export figures in Trade of Canada are valued f.o.b. point of shipment. For interindustry study, it was assumed that this was equivalent to the value f.o.b. the producing establishment and no adjustment was made to arrive at producers' value. However, adjustments were made to the values of exports of the agricultural industry and of the meat processing industry to bring them to an estimated value f.o.b. the farm or f.o.b. the manufacturer. Exports of farm products were valued at farm prices; and 13 percent of the value of exports was added to exports of meat products.

For import figures 9 percent of total imports was added to raise the level of valuation to c.i.f. Canadian border.

ML11 Inventory changes. In this study, figures on inventory changes are of three kinds. For agricultural sectors, only inventory changes on the farm were considered. The inventory changes in agricultural processing and furnishing industries were compiled by subtracting the amount of the factory shipments from the total production. The data on inventory changes in agricultural sectors were obtained directly from DBS, Agricultural Division. Those for industrial sectors were available in (18), (19) and other related DBS publications. The inventory changes in 'gross domestic inputs' row were found in (31) and (32).

ML13 Household consumption. Household consumption of products of 'cattle' and 'hogs' sectors were those of farm income in kind. It was assumed that the majority of these products were processed in the meat processing industry before being consumed.

For agricultural sectors entries in 'labor' row were adapted from data available in (6). In the first place, figures on labor income from agriculture were found in (32) for the years concerned. Carter's estimates (6) were then used to calculate the share in livestock production along with other agricultural sectors. Derivation of figures for 'cattle' and 'hogs' sectors were based on percentages of farm cash income from cattle and hogs as of total livestock production.

TABLE XXVIII

VALUES OF LABOR INPUTS IN AGRICULTURAL SECTORS
1941, 1951 AND 1961
(millions of dollars)

	1941	1951	1961
Agriculture	86	157	195
Livestock	42.7	78.0	96.9
Feed grains	8.6	15.7	19.5
Food grains	2.6	4.7	5.8
Forage crops	5.0	9.1	11.3
Cattle	9.6	26.4	34.1
Hogs	12.3	17.6	16.9

Sources: Calculated from data contained in (31) and (32).