30319

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TITLE OF THESIS/*TITRE DE LA THÈSE* STRUCTURAL CHANGE, KEY SECTORS AND LINKAGE-BALANCED GROWTH: AN INPUT-OUTPUT ANALYSIS OF THE CANADIAN ECONOM

UNIVERSITY/*UNIVERSITÉ* SIMON FRASER UNIVERSITY.

DEGREE FOR WHICH THESIS WAS PRESENTED/ *GRADE POUR LEQUEL CETTE THÈSE FUT PRÉSENTÉE* Ph. D.

YEAR THIS DEGREE CONFERRED/*ANNÉE D'OBTENTION DE CE GRADE* 1975

NAME OF SUPERVISOR/*NOM DU DIRECTEUR DE THÈSE* Dennis R. Maki.

DATED/*DATÉ* Nov: 21/75 SIGNED/*SIGNÉ*

PERMANENT ADDRESS/*RÉSIDENCE FIXÉ* [redacted]

NL-91 (3-74)

STRUCTURAL CHANGE, KEY SECTORS AND LINKAGE-BALANCED GROWTH: AN INPUT-OUTPUT ANALYSIS OF THE CANADIAN ECONOMY

by

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in the Department

of

Economics and Commerce

SIMON FRASER UNIVERSITY

November 1975

APPROVAL

Name: Aftab Ali Syed

Degree: Doctor of Philosophy

Title of Thesis: Structural Change, Key Sectors and Linkage-Balanced Growth: An Input-output Analysis of the Canadian Economy.

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Title of Thesis/Dissertation:

STRUCTURAL CHANGE, KEY SECTORS AND LINKAGE-BALANCED GROWTH: AN INPUT-OUTPUT ANALYSIS OF THE CANADIAN ECONOMY.

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ABSTRACT

This thesis is concerned primarily with the analysis of changes in the structure of the Canadian economy between 1961 and 1966. As a by-product of the major endeavour, it also examines the notion of 'linkages' which have been utilized to identify key industries in the economy. Further, the empirical content of the concept of balance/imbalance in growth theory has been applied to determine sectoral balance/imbalance in the economy during the 1960's.

Input-output tables of the Canadian economy for 1961 and 1966 provide the framework of analysis for this study. These tables are based on an input-output model of the Canadian economy published by Statistics Canada.

Findings of the analysis show that changes in gross production and intermediate outputs arise not only from changes in the bill of final demand, but are also due to changes in the coefficients of production. Analysis of the inverse matrices indicates intermediate output requirements per unit of output have declined from 1961 to 1966 on average. Analysis of the magnitude of change in direct coefficients between 1961 and 1966, at the industry level, reveals that small changes occurred in 60 out of the 75 industries examined. The most pronounced changes occurred in metal mines, pipeline transport, radio and T.V.; and in two utilities, gas and water. Using weighted indices to measure the direction of change at the industry level, it is found that on the average, input ratios increase by 0.4 per cent.

Results of the analysis of key industries show that the number of key industries identified was larger in 1966 than in 1961. Key industries identified on the basis of technological considerations were different from those identified on the basis of final demand considerations.

The analysis of sectoral balance/imbalance in the Canadian economy during the 1960's indicates that 10 out of a total of 72 industries examined deviated from the overall rate of growth by more than 10 percentage points. Included among these were: miscellaneous transport equipment with the highest deviation of 72.9 percentage points followed by truck bodies and trailers with a deviation of 35.2 percentage points. Analysis of the linkage-balanced growth proportions reveals that 22 (out of 72) industries deviated from linkage-balance by more than 10 percentage points. Two industries showed very large positive deviations. These were: miscellaneous transport equipment with a deviation of 61.3 percentage points, followed by truck bodies and trailers with a deviation of 22.7 percentage points.

ACKNOWLEDGEMENTS

Stimulating working environment of the Structural Analysis Division of Statistics Canada provided an impetus to the completion of this study. I wish to acknowledge my debt to Mr. Rob Hoffman, Director of the Division. I am also grateful to all the members of the staff for their moral support, encouragement and useful discussions.

I must acknowledge my debt to Professor Dennis R. Maki, senior supervisor of my thesis committee, for his guidance, constructive criticisms and valuable suggestions. I am also indebted to Professor Mahmood H. Khan for his constructive comments and suggestions.

Any residual errors or ommissions are, however, author's responsibility.

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CHAPTER 1

INTRODUCTION

The important role of intermediate inputs in the production process does not seem to have been reflected in a commensurate weight of economic analysis. In fact, a recent volume on production functions edited by Brown (1967) -- impressive both for its size and for the distinction of its contributors -- does not contain a single reference to the treatment of intermediate inputs. The general practice is to concentrate upon labour and capital to the exclusion of intermediate inputs for which, after all, information is harder to find, more fragmentary, and more difficult to process. However, many practical problems of business and government require an understanding of how, and at what rate, the use of materials and service inputs is changing. Indeed, it is difficult to conceive of studying some central aspects of technical change without introducing specific intermediate inputs.

Input-output tables provide a detailed accounting of the amounts of goods and services that individual industries buy from and sell to each other, and therefore constitute a useful medium for the analysis of inter-industry relationships. The structure of production of an economy, in an input-output framework, is represented by input-output (I-O) coefficients. Given the I-O type production relationships over time, changes in the underlying structure can be analyzed. Since the pioneering work of Leontief (1953) a number of studies analyzing structural change in an I-O framework have appeared.[1)] Notable among these is an exhaustive study by

1) These studies are reviewed in chapter 2 of this study.

Carter (1970), who has analyzed changes in the structure of the U.S. economy in a Leontief I-O framework. The principal novelty of Carter's (1970) study lies in its explicit concern with intermediate inputs in the analysis of changing economic structure.

The analysis of structural change in the Canadian economy presented in this study relies in part on the analytical framework suggested by Carter (1970). Unlike her analysis, ours is based on a rectangular I-O framework. It is, as far as the author is aware, the first study of this kind to examine structural change in the Canadian economy. This study is intended to be primarily empirical in nature, and no distinction is made between structural change and technological change. A considerable literature dealing with this distinction at a highly theoretical level exists, and economic practitioners like Manne and Markovitz (1963) and Carter (1970) discuss various phases of the relation between technology and economic production functions. In opting for the neutral and unambiguous term of "structural change" we are following convention in empirical work and seek to study changes in parameters of a particular form of production function, the I-O type.[1)]

The principal objective of the study is to analyze changes in the structure of the Canadian economy using input-output tables for the

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1) See Solow (1957) on this point.

years 1961 and 1966. Two broad aspects of structural change which are examined directly are: (a) changes in the gross production values arising both out of changes in the bill of final demand and from changes in the coefficients of production; and (b) changes in the intermediate output levels required to satisfy a given bill of final demand. However, these direct measures which identify sources of structural change tend to rely on the inverse matrices of the input coefficients employed. Consequently, structural change is measured through an analysis of the inverse matrices themselves. Following Rasmussen (1957), we utilize "summary measures" of structural change.

Even though the main objective is an analysis of structural change, it is demonstrated that the input-output framework proves useful in two additional dimensions. First, the analysis of structural change based on inverse matrices allows the possibility of exploring the notions of 'linkages' and 'key industries'. Accordingly, measures analogous to Hirschman's (1958) 'backward' and 'forward' linkages are developed and used to determine key industries in the Canadian economy. Since another manner in which key industries have been determined is by the utilization of final demand, the results of these identification procedures are contrasted.

Secondly, the latter analysis in turn suggests a useful approach to a quantitative description of an economy over time. Swamy (1967), and Yotopoulos and Lau (1970) defined operationally the concept of sectoral imbalance in terms of the dispersion of sectoral growth rates from the overall rate of growth of an economy. Yotopoulos and Nugent (1973) modified this measure of sectoral imbalance by incorporating into it linkage effects of the I-O type. Their modification considers a maximum degree of imbalance that reflects also the sectoral linkage index: a sector grows differentially from other sectors precisely due to existing differences in linkage indices. Previous studies have investigated cross-sectional differences in sectoral growth rate imbalances among a number of countries over time. We rely on some of the formulations employed in these studies to investigate imbalance in one country, Canada, during the period of 1960's. Industries which are strong contributors to imbalance are distinguished.

In chapters 2 to 5 the analysis of structural change is presented. A brief review of some of the earlier studies that deal with the analysis of structural change in an I-O framework is presented in chapter 2. Chapter 3 deals first with the theoretical aspects of the I-O model that underly the construction of rectangular I-O tables for the Canadian economy. Various indices are then formulated for the measurement of structural change in the economy. In chapter 4, empirical findings based on these indices are presented and discussed. Formulation of the indices of change in chapter 3, and discussion of findings based thereon in chapter 4, necessitate an examination of the changes in direct coefficients of production themselves as precursors of change. Chapter 5 therefore presents an analysis of changes in the coefficients of the technology matrix between 1961 and 1966. Chapter 6 deals with structural linkages and identifies key industries in the Canadian economy from the viewpoint of technology and final demand. In chapter 7 we first discuss briefly some empirical studies dealing with the concept of balance/imbalance ; secondly, these concepts are utilized to describe quantitatively the growth pattern of the Canadian economy during the 1960's. Chapter 8 is a concluding chapter in which some implications of the major findings of the study are discussed.

CHAPTER 2

A BRIEF REVIEW OF SOME EARLIER STUDIES OF STRUCTURAL CHANGE USING THE INPUT-OUTPUT APPROACH

While economics of technological/structural change has only recently become fashionable, there is already a growing body of literature that clearly distinguishes itself from other specializations in economics (see Lave (1966) for a thirteen page bibliography on the subject). Input-output analysis has, over the years, found an important application in the study of structural change. The structure of production, in an input-output framework, is represented by input-output coefficients. And, although the technical characteristics of the particular system may vary, these coefficients are generally termed "technical coefficients" of production. Given input-output type production relationships over two or more points in time one can discern changes in the underlying structure.

Economic systems with identical sets of input coefficients can be said to be structurally identical. Structural change, therefore, is a change in the structural matrix of the system (Leontief, 1953). According to this terminology an increase or decrease in the output of any industry can be caused by: (a) a change in the given bill of final demand; (b) a change in the production structure of the system; or (c) by a combination of both.

The procedures adopted to measure structural change in this study find their precedence in the earlier works of Leontief (1953); Carter (1967, 1970); Vaccara (1970) and Staglin and Wessels (1972). A brief review of the relevant aspects of these studies is presented below. In general, these studies examine two specific questions: (1) how has the structure of production (depicted in input-output tables) of an economy actually changed between two or more points in time, and (ii) how did this change affect the outputs of separate industries. An enquiry into the causes of structural change in itself is omitted. This could only be studied in a more comprehensive theoretical framework.

The earliest application of the input-output technique to the analysis of structural change is attributable to Leontief (1953). He analyzed the structure of the American economy for the decades of 1919-29 and 1929-39. Changes in direct technical coefficients were first explained as the difference between original and final magnitudes - in a base year and a subsequent year, respectively.[1)] He demonstrated that a negative change - i.e., a reduction in the input requirements per unit of output, can be loosely described as an increase in productivity. Since the distributions computed were nearly normal he used their means as a statistical measure of the magnitude of overall change. He found that from 1919-29 the input coefficients in all industries were on average reduced by 14 per cent; whereas in the following decade of 1929-39 the

1) Leontief has used the following formulation: if a_{ik} and a'_{ik} are the two magnitudes of a particular input coefficient, then the index of the relative change $\bar{a}_{ik}$ is given by $2(a_{ik} - a'_{ik}) / (a_{ik} + a'_{ik})$. For the computed distribution of relative change in technical coefficients, these indices of change, $\bar{a}_{ik}$, are entered with the weights $(x_{ik} + x'_{ik})/2$. a_{ik} and a'_{ik} are technical coefficients that show, for both base year and current year respectively, the amount of each particular input absorbed by that industry per unit of its output. x_{ik} and x'_{ik} are the corresponding amounts of products of industry i absorbed by industry k $(i = 1,\dots,m;\ k = 1,\dots,m)$.

reduction registered amounted to only 11 per cent. Thus it was concluded that the rate of technical progress was slower in the period of the great depression than during the preceding years of the great boom. Although the input ratios in most cases showed a consistent decline, for almost every individual industry some ratios were increasing while others declined. This phenomenon relates directly to the question of factor substitution vis-a-vis technical change.[1] Without emphasis, and in a very cautious manner, Leontief concludes that a reduction in any one or more coefficients, with the rest of the structural matrix remaining the same, will always result in a more efficient utilization of resources (Leontief, 1953, p.32). This allows the production system to produce any given bill of goods with smaller total outputs (and since the bill of goods is fixed, with smaller total inputs also) of all commodities and services.

The phenomenon of observed increase in input ratios deserves special mention. In most cases, the increase in the technical coefficients of certain kinds of inputs is associated with a reduction of the input ratios of some other commodities or services absorbed by the same industry. The adoption of a new method of production involves a simultaneous change in all input ratios and the reduction of some could not be realized without corresponding increases in others. In short, a whole new column of

1) This problem has been thoroughly and definitively explored by the traditional theory of production; linear programming with alternative factor combinations reformulates the same problem as well.

coefficients - representing (within the structural matrix of the whole economy) the technical characteristics of the particular industry - is being substituted for the old one. Other columns might or might not be changed at the same time.

Leontief, having thus defined structural change, performed a series of computations to measure the effects of structural change. The underlying assumption is that individual industries are structurally independent of each other in the sense that the technical possibility of substituting a new set of coefficients in any one column of a given structural matrix is in no way conditioned by the changes which might take place in any other column of the same matrix. The computations, describing the changes in total outputs required to produce some fixed bill of final demand, show the separate and combined effects of structural change that actually took place in the productive sectors of the American economy during the period in question. Leontief showed that the 1939 bill of final demand, if produced on the basis of 1929 techniques, would have required 1287 billion man-hours more than were actually absorbed. Leontief's major contribution is to show that, in an I-O framework, the total change within an open system can be factored out in two parts: one due to its structural variations and the other necessarily assigned to the change in the bill of goods itself.

Carter (1967), along the line of Leontief's (1953) work, studied changes in the structure of the American economy for the period 1947-58 and 1962. Applying the 1947 and 1958 technologies to the fixed bill of goods of 1962, the overall changes in direct and indirect requirements to produce this bill of goods were determined. Changes in the output levels of 73 industries were analyzed.[1] Although the approach used in this study is similar to that of Leontief (1953), an interesting feature of Carter's analysis is the examination of changes in the production structure based on the ten-order disaggregation of the final demand vector in terms of end-product groups. She noticed marked differences in the impacts of technological change on the inputs required to produce different types of end products. The general conclusion of the study is that those sectors which change most (i.e., those with greatest relative change) change in the same direction.[2] Relatively greater total change affects direct plus indirect requirements for durable goods deliveries to final demand, and relatively less total change affects deliveries of food, textiles, services and construction. In fact there has been a net increase in total input requirements (an increase in the "indirectness" of production) for all sub-vectors of final demand,[3] except the services sub-vector. However, the increase in indirectness is smaller for drugs, soaps and paper, and electrical machinery than it is for other kinds of products.

1) In her study neither the I-O table nor the final demand for 1962 were available. Actual outputs are taken to represent the total direct plus indirect requirements. The bill of goods for 1962 is an estimate. Output levels for 1947 and 1958 have been estimated by multiplying the estimated 1962 final demand vector with respective (I - A) inverse matrices.

2) This is partly a matter of arithmetic - net change tends to be greatest where all the change is in the same direction (Carter, 1967, p.214).

3) The sub-vectors of final demand are: food and tobacco; textiles and clothing; drugs; furniture; consumers' appliances; construction; non-electrical producers' durables; transport equipment; and services excluding utilities.

It is shown further in the analysis of structural change that changing methods of production warrant a new division of labour among industries. As new industrial specialization patterns become advantageous, they gradually supplant the old ones. In this connection Carter (1967) discusses two trends that emerge from the analysis: (a) the rise in the importance of general inputs, and (b) changing patterns of material use.[1)] A comparison has been made of the amounts of general inputs, chemicals, materials and metal-working inputs required to produce the 1962 bill of final demand with 1947, 1958 and 1962 technologies. Her findings are that between 1947 and 1958, and again between 1958 and 1962, the three kinds of general inputs (energy, printing and publishing, and services) and chemical requirements increase, while materials decrease in general importance and the total volume of metal-working activity remains virtually constant. The reasons for the increase in general inputs are obvious: a firm keeps records, communicates with other firms and markets its products; and it buys the services of labour and capital, uses buildings and equipment that must be maintained, heated and powered. Chemicals share features of both general inputs and material inputs as they are bought directly by a great majority of industries. The reason for the decline in the use of materials (ferrous and non-ferrous metals, stone and clay products, plastics and rubber etc.) is the marked tedency towards diversification. With one minor

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1) General inputs are those that include energy, printing and publishing, and services as being used by all sectors of the economy. Other (specific) inputs are categorized as chemicals, materials (plastics and synthetics) and metal-working inputs (electronic components, structural metals etc.).

exception (non-ferrous metals in electrical machinery) the percentage share of the most important material is always smaller with 1958 than with 1947 technology.

Over the years a number of economists have held the view that in several developed economies there exist certain essentially independent productive complexes or blocks, each oriented toward the processing of a particular material.[1] The results of Carter's study run counter to this view. She has shown that the diversification of materials reduces the independence of individual blocks in the American I-O tables analyzed.

Carter also published an exhaustive study (1970) in which I-O tables of the U.S. economy for the years 1939, 1947 and 1958 were analyzed. Part I of the book deals with structural change in industrial specialization in terms of intermediate input structure. The method of analysis and the format of presentation of the results are similar to her 1967 study described earlier. The summary measures of structural change that have been computed follow the same logic: what would be the amounts of individual inputs required to deliver a fixed bill of final demand with the input-

1) Simpson and Tsukui (1965), in an international comparison of I-O tables, have demonstrated that there are certain fundamental elements which may be found in the productive structure of modern economic systems to be purely technical in character. Although the economic systems of Japan and the U.S. are operationally dissimilar they observed almost identical patterns of industries. The most striking feature noticed was the existence of separable blocks of production, such as blocks composed of metal industries, energy industries, services industries, etc.

output coefficients of successive years.[1] Many variants of this type of measure are studied and discussed. Some general conclusions, similar to her earlier findings, are: over time, the economic system requires less and less labour and capital to produce a fixed final demand, and labour and capital productivity improve; and total intermediate outputs required to produce a fixed final demand remain fairly stable and increase slightly over time - implying that somewhat greater indirectness or specialization comes with technological change.[2]

Part II of Carter (1970) deals with structural change and economic efficiency. The analysis of change is presented in terms of total primary factor requirements - labour, capital and replacement coefficients have been used. She finds that both labour and capital coefficients are falling in most sectors, with capital falling generally more slowly. No evidence is found of improvement in labour productivity in proportion to the changing capital intensity, however. Within the same realm she distinguishes direct primary factor saving from "adaptive change". The latter term implies economies in primary factors arising from reshuffling intermediate

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1) Each year's inverse matrix measures total requirements with that year's input structure in all sectors, per unit delivery to final demand. Multiplying the inverse coefficients along each row by a final demand vector of given level and composition yields estimates of total output requirements to deliver that particular bill of final demand. Total intermediate requirements from each sector are obtained by simply subtracting the specified final demand vector from the estimated vector of total output requirements. Thus it is possible to postulate any given historical or hypothetical bill of final demand and study how intermediate requirements for any sector's output change with changing input-output structure.

2) This is in contrast to the "golden age" proportional growth thesis (Phelps, 1966). Carter finds decided changes in the relative importance of individual intermediate sectors in the total.

input requirements to take advantage of differential rates of improvement in other sectors. The conclusion is reached that adaptive change depends on the price mechanism. For purposes of determining the efficiency of the productive system she makes use of the linear programming technique, and computes the optimal mix of new and old input structures. The 1947 and 1958 structures are treated as alternatives for each sector. It is demonstrated that a significant portion of structural change between 1947 and 1958 resulted from the assimilation of new techniques rather than classical substitution. Within a wide range of primary factor price variations, most 1958 industrial structures were superior to those of 1947. Using hybrid matrices - composed of 1947 structures for some sectors and 1958 structures for others - she determines the extent to which the advantage of a new structure in one sector depends on the introduction of new structures in others. Her finding is that, by and large, each new structure is better than its older counterpart, even ignoring developments elsewhere in the system. Adaptive change adds to its advantage but does not change its direction. This generalization, she contends, is based on the relative importance of direct labour saving in the structural change of most sectors.

In summary, the major findings of her study are: the overall proportion of intermediate to final production showed little change, but systematic shifts did appear in the relative contribution of individual industries; most structural change was the result of assimilation of new techniques rather than classical substitution; and, in general, direct labour-saving was large relative to changes in capital and intermediate requirements. This is the first study of the U.S. economy in which concrete developments in technology have been tied to the broader economic picture.

Changes over time in input-output coefficients for the United States have also been studied by Vaccara (1970). In this study various measures of the degree and direction of coefficient change over time are applied. It follows the earlier approaches to measuring change in that it compares the outputs required from each industry to produce a fixed bill of final demands (that of 1958) with 1947, 1958 and 1961 technologies. Vaccara found that, on the average (and ignoring signs), there was a 16 per cent difference in the outputs required from each industry to produce the 1958 bill of goods with the 1958 technology, as compared to the 1947 technology. Notwithstanding this average impact, for a few industries, such as plastics and synthetic materials, and machine shop products, these differences in output requirements exceeded 75 per cent. On the other hand, for many important industries, such as paper and petroleum products, the change in output requirements was less than 5 per cent.[1)]

It was shown to be a more meaningful to examine the impact on production of changes in I-O coefficients over time by concentrating on

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1) Since the procedure used involves the application of same set of final demands to different inverse matrices it is to be expected generally that industries selling primarily to final consumers will register smaller percentage changes over time in total requirements - new construction, for example, sells its output entirely and directly to final demand - than industries that sell primarily to other producing industries.

change in intermediate rather than in total output requirements. Vaccara, in this study, found an average change between 1947 and 1958 in intermediate output requirements of almost 30 per cent in contrast to the overall change of 16 per cent in total output requirements. The change over the three-year period 1958-61 in the intermediate output required to produce the 1958 bill of goods was considerably smaller (as might be expected) than over the eleven-year period 1947-58. During the latter period, the average annual rate of change in intermediate output requirements (ignoring signs) was 2.3 per cent. Over the 1958-61 period, the difference in intermediate output requirements for a fixed bill averaged 1.7 per cent per year. In general, this study found that there was a systematic relationship between the direction of change in the industry intermediate output requirements for the two time periods examined. Of the thirty-six (out of the 64 industries examined) industries that showed positive increases in output requirements between 1947 and 1948, 26 showed positive increases between 1958 and 1961; 22 of the 35 industries with negative change between 1947 and 1958 also showed negative changes between 1958 and 1961. Moreover, the majority of the 23 cases with changes in the opposite direction in the two periods occurred in industries where the changes in output requirements were small in both time periods.

Although the analysis based on combined direct and indirect effects of coefficient change (using inverse matrices) is valid for summarizing the impact on a given industry's production of various changes in input coefficients for all industries, it may not be a true guide to the degree or direction of change in the direct requirements for the output of the given industry.[1] It is thus important to measure the separate impact on an industry's output requirements of changes over time in the direct input coefficients. Vaccara conducted such an analysis,[2] and her comparison with the changes based on inverse matrices reveals that on the average, percentage changes in intermediate output requirements based on inverse and direct coefficients are quite similar. For the period 1947 to 1958, changes in intermediate output requirements for 58 industries average 28 per cent based on the inverse and 26 per cent based on the direct coefficients. For the 1958 to 1961 period, the average change was a little over 5 per cent. There was a sizeable difference, however, between the two methods and the measures differed more for individual industries. The average annual rate of change in intermediate output requirements differed by one per cent for 20 of the 58 cases examined in the 1947-58 period, and for 16 of the 58 cases in the 1958-61 period.

An inter-temporal analysis of structural change in the German economy has been conducted by Staglin and Wessels (1972). Following the

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1) This was really the case in the study being reviewed here (for the iron ore industry). The combined direct and indirect effects on the intermediate output requirements for iron ore changed very little between 1947 and 1958. In reality, however, there was a 23 per cent increase in the direct requirements for iron ore. This increase was almost entirely offset by the sizable decrease in requirements for steel. In other cases, the direct and indirect impacts may reinforce one another, and thus, the combined impact of changes may be considerably larger than the changes in the direct coefficients.

2) The measures are derived by multiplying the actual 1958 total output for each industry, in turn, by 1947, 1958 and 1961 direct coefficient matrices.

approaches used by Carter and Vaccara, they studied I-O tables of the German economy for the years 1954, 1958 and 1962. These tables relate to 56 production sectors, 7 final demand categories and 5 primary inputs. Structural change was measured both as a result of change in the bill of final demand and due to coefficient change. Analyzing the total period (1954-62) and comparing structural change between the two sub-periods, they found that overall gross production during both sub-periods (1954-58 and 1958-62) increased by nearly the same amount. The average annual rate of change was 7.5 per cent in 1954-58 and 7.1 per cent in the 1958-62 period.

As a result of changes in the final demand they found certain 'waves' responsible for differences in production levels in the two sub-periods. For example, the so-called "eating-wave" in the 1954-58 sub-period was shown to result in higher indices in food, beverages and tobacco industries.

A comparison of changes in gross production due to coefficient change during the two periods revealed a higher overall rate in the first sub-period (-3.1 per cent) than in the second (-0.2 per cent). Of the 56 industries examined, 39 industries showed decreases in gross production due to coefficient change between 1954 and 1958, while only 27 revealed negative changes between 1958 and 1962.

A comparative analysis for intermediate output requirements to deliver a fixed bill of final demand (for 1962) with different technologies was also performed. The results obtained corresponded with those obtained for the gross production levels - considerably smaller change in the 1958-

62 period than between 1954 and 1958. These were as expected since the requirements to satisfy the 1962 bill of goods tend to be smaller with newer than with older technology (as measured by the respective inverse matrices).

Staglin and Wessels compared the results of their analysis of the German economy with those of Carter's (1970) for the U.S. economy. The intermediate output levels required to deliver the 1962 bill of goods with 1954, 1958 and 1962 technologies in Germany were compared with the intermediate output requirements for delivering 1961 final demand with 1947, 1958 and 1961 technologies in the U.S. Although the inter-country comparison is restrained by different periods and different price deflation, the results show a surprising correspondence in requirements for both economies. These are reproduced below:

	German economy.			U.S. economy.		
	1954	1958	1962	1947	1958	1961
		(%)			(%)	
General industries	33.2	34.9	35.8	30.4	31.6	32.4
Materials	24.0	23.0	23.2	30.9	26.9	26.3
Metal-working	11.4	12.1	13.4	11.1	12.6	12.6
Chemicals	5.1	5.6	5.6	3.7	5.1	5.5
All other	26.3	24.4	22.0	23.9	23.8	23.2
Intermediate output required	328	300	299	336	337	334
	(billions of DM-1962 prices)			(billions of US $ - 1947 prices).		

Source: Staglin and Wessels (1972, p.391).

All five groups, in both countries, reveal almost the same tendency in intermediate output change: during the period in question inputs (or outputs) from general industries, metal-working, and chemicals are expanding steadily, whereas materials and all other industries tend to decline in their intermediate output levels.

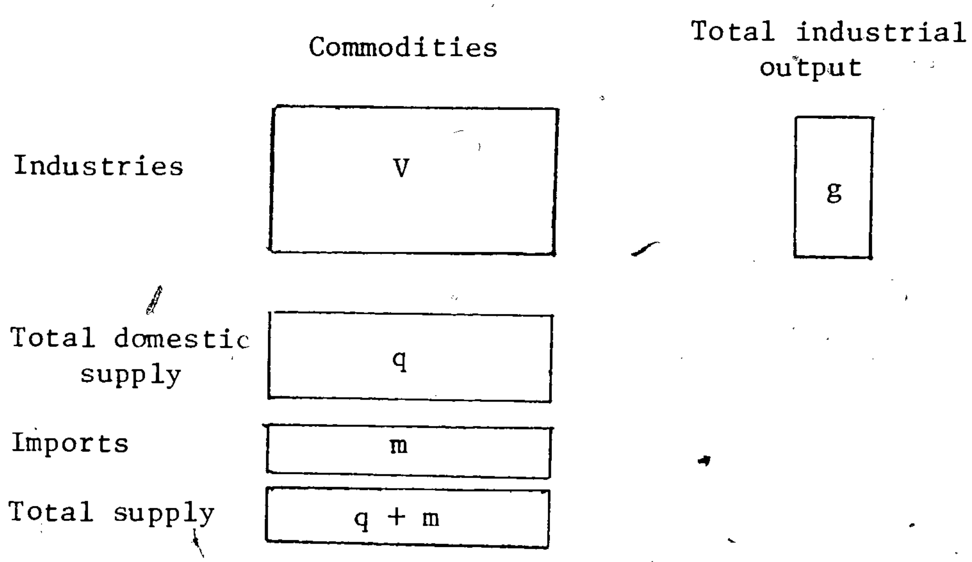
CHAPTER 3

AN INPUT-OUTPUT MODEL OF THE CANADIAN ECONOMY AND FORMULATION OF INDICES MEASURING STRUCTURAL CHANGE

In this chapter we describe an input-output model of the Canadian economy which forms the basis for the input-output tables for 1961 and 1966 which are analyzed in this study. Next, we formulate various indices which are used to measure structural change in the Canadian economy.

Diagramatically, the I-O accounts and related coefficients tables can be represented as follows:

SUPPLY



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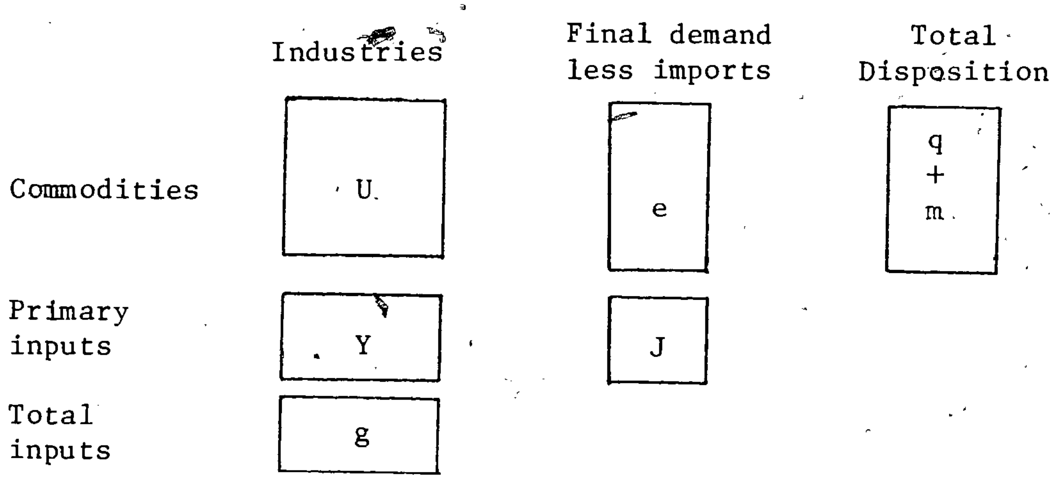

Notation used:

V - matrix showing the domestic output (gross value of production) of industries by commodities.

U - matrix showing the use of commodities by industries.

g - vector of industry outputs - row sums of V which is equal to the column sums of U plus column sums of Y.

q - vector of domestic output of commodities - column sums of V.

m - vector of imports by commodities.

e - vector of final demand less imports.

Y - use of primary inputs by industries.

J - use of primary inputs by final demand.

(All values in the tables are expressed in producers' prices).

The Canadian system of I-O accounts[1)] distinguishes 644 commodities, 187 industries, 91 categories of final demand and 8 primary inputs. It is set out in a rectangular framework in which industries produce characteristic products and, in many instances, secondary products. This study, however, utilizes a different level of aggregation in that it distinguishes 75 industries, 115 commodities, and 169 categories of final demand that have been compressed into one vector (e). We also distinguish 8 primary inputs.[2)]

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1) For an excellent exposition of the Canadian I-O accounts see Statistics Canada, catalogue 15-501, Occassional, "The Input-Output Structure of the Canadian Economy 1961", Ottawa, 1969.

2) This classification is similar to the one employed in the CANDIDE model used at the Economic Council of Canada. See Waslander and Syed (1975).

The basic identity of the model states that, for each commodity i, total supply is equal to total disposition:

domestic output + imports = intermediate demand + final demand.

If we let:

$q = (q_i)$ = vector of domestic output by commodity;

$e = (e_i)$ = vector of final demand less imports.

$U = (u_{ij})$ = matrix of intermediate demands by industry j for commodity i

we may write the identity:

$$q_i = \sum_j u_{ij} + e_i \qquad (3.1)$$

The structural parameters of the model are obtained on the basis of the following assumptions:

(i) <u>Industry technology</u>: This states that the intermediate inputs are proportional to <u>total</u> industry outputs, and are therefore independent of the commodity composition of these outputs. This can be written as:

$$u_{ij} = b_{ij}\, g_j \qquad (3.2)$$

where: b_{ij} = the amount of commodity i required to produce one unit of output of industry j; B = matrix with elements b_{ij}.

g_j = vector of industry outputs.

(ii) <u>Fixed market shares</u>: This assumption relates commodity and industry outputs and states that the market shares of industries for each commodity are fixed. This can be written as:

$$v_{ji} = d_{ji} q_i \qquad (3.3)$$

where:[1)]

v_{ji} = the amount of commodity i produced by industry j; V = matrix with elements v_{ji}.

d_{ji} = j-th industry's share in the market of commodity i; D = matrix with elements d_{ji}.

q_i = vector of domestic output by commodity.

Combining equations (3.1) to (3.3) we may write:

$$q = Bg + e \qquad (3.4)$$

$$g = Dq \qquad (3.5)$$

This system of equations has the following solutions:

$$q = (I - BD)^{-1}e \qquad (3.6)$$

$$g = (I - DB)^{-1}De \qquad (3.7)$$

The Canadian I-O model as set out in equations (3.6) and (3.7), like the traditional Leontief-type I-O model, measures the impact of a change in the bill of final demand upon the output levels of industries - equation (3.7). Unlike the Leontief-type models, however, the Canadian model has the advantage of obtaining a solution in the commodity space as well - equation (3.6). Further, the Canadian I-O model has the advantage of not forcing the dimensions of matrices to be necessarily square as does Leontief's formulation. Hence, the industries are allowed to produce more than one commodity; alternatively, one commodity can be produced by many industries.

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1) Subscripts i and j refer to commodities and industries respectively unless otherwise stated.

3.1 INDUSTRY-TECHNOLOGY, COMMODITY-TECHNOLOGY AND THE RESEMBLANCE OF MATRIX (DB) IN CANADIAN MODEL AND MATRIX (A) OF LEONTIEF'S MODEL

The standard solution of Leontief's I-O model that expresses industry outputs (X) as a function of final demand for industry products (f), given the matrix of intermediate input coefficients (A), industry by industry, is written as:

$$X = (I - A)^{-1} f \qquad (3.8)$$

Let us compare equations (3.8) and (3.7). In equation (3.7), since e is a vector of final demand in commodity space, (De) is its transformation into the industry space; besides, DB is an industry by industry input matrix, the columns of which represent the inputs into an industry which come from other industries, following the assumption of fixed market shares. Therefore, under the industry technology and fixed market shares assumptions, the industry by industry input matrix which corresponds to the A matrix in the Leontief system is the (DB) matrix of the Canadian system.

Commodity technology models are based on the assumption that there is only one way of making each commodity, whatever the industry that produces it. Thus, the input structure of an industry will be a weighted average of the input structures of the commodities it produces, the weights being the product-mix coefficients of the industry:

$$b_{ij} = \sum_k a_{ik} \, p_{jk} \qquad (3.9)$$

or $\qquad B = AP$

P is defined by:

$$v_{ji} = p_{jk} g_j$$

where:

a_{ik} = commodity input matrix; a_{ik} is the amount of commodity i required to produce one unit of commodity k; A = matrix with elements a_{ik}.

p_{jk} = matrix of product-mix coefficients; p_{jk} is the proportion of the output of industry j which is made of commodity k; P = matrix with elements p_{jk}.

Provided P is square (commodities being defined as the principal products of industries), and P^{-1} exists, the input matrix representing the commodity technology will be:

$$A = BP^{-1} \qquad (3.10)$$

The A matrix defined in (3.10) can be considered as the A matrix of Leontief's transformation (3.8) which is then a transformation from final demand to output in commodity space, under the assumption of commodity technology.

The I-O matrices analyzed in this study are at market prices and represent the current year dollar flows (and the coefficients derived from them). There is controversy in the literature as to whether I-O tables based on the value coefficients are better for analytical purposes than their counterparts prepared in volume terms, as the following section shows.

3.2 VALUE COEFFICIENTS VERSUS VOLUME COEFFICIENTS

Despite the fact that volume coefficients may have historical priority (in the sense that input-output theory was originally cast in terms of volumes in constant prices, or even physical units) there are still two good reasons for analyzing value rather than volume. One is a pragmatic reason. Value coefficients are directly available and volume coefficients are not. Assuming that value coefficients could be deflated by suitable price indexes, it is still doubtful if one may obtain volume coefficients of quality comparable to that of the value coefficients. The second reason is a theoretical one. It is the consideration that it is probable that value coefficients are on the whole at least as stable, or even more stable, over time than volume coefficients. This reasoning is substantiated by the findings of Tilanus (1966, chapter 5). In his analysis of the Dutch economy based on thirteen I-O tables (1948-61) he finds that predictions based on value coefficients are generally better than predictions based on volume coefficients.

3.3 MEASURING STRUCTURAL CHANGE: SOME PROCEDURES

In this study, structural change means changes in the I-O structure of the Canadian economy between 1961 and 1966. Changes in coefficients, as reflected in I-O tables, can be caused by many factors. One of these is technological change, a change in the physical requirements of the inputs for producing a fixed basket of goods. Another important factor that could cause change over time in the coefficients for a given industry is changing "product mix". The level of aggregation of the I-O tables can also affect the stability over time of the various coefficients. A complete analysis of coefficient change should attempt to factor out these various causes by relating them to underlying forces such as changes in consumer tastes and technological innovations. This would be a long range, large scale project and is beyond the objectives of this study.

3.3.1 DIRECT MEASURES OF STRUCTURAL CHANGE

We study two aspects of structural change by examining two of its broad aspects: (i) changes in the gross production values (hereafter called GPV) arising out of changes in the bill of final demand and from changes in the coefficients themselves; and (ii) changes in the intermediate output levels required to satisfy a fixed bill of final demand. The following procedures are developed for this analysis.

PROCEDURE I

Let us rewrite equation (3.7) as follows:

$$g^t = C^t y^t \qquad (3.11)$$

where:

$$C^t = \{ (I - DB)^{-1} \}^t$$
$$y^t = (D^t e^t)$$
$$(t = 1961, 1966)$$

Changes in the GPV can be factored out as (a) a change in the bill of final demand and (b) changes in the coefficients themselves. In this study we use C^{66} as fixed. If we multiply 1961 final demand (y^{61}) by the 1966 inverse (C^{66}) and compare the derived 1961 GPV (C^{66} y^{61}) with the actual GPV in 1966 (C^{66} y^{66}), the comparison shows changes in the GPV due solely to the change in final demand.

If, however, we compared the derived 1961 GPV ($C^{66} y^{61}$) with the actual GPV in 1961 ($C^{61} y^{61}$), the comparison would indicate changes in GPV solely attributable to changing coefficients. The procedure can be described by the following equation:

$$C^{66}y^{66} - C^{61}y^{61} = (C^{66}y^{66} - C^{66}y^{61}) + (C^{66}y^{61} - C^{61}y^{61}) \qquad (3.12)$$

PROCEDURE II

To determine changes in the intermediate output requirements (i.e., comparison of technologies) for satisfying a fixed bill of demand, we write:

$$'Q^{66} = C^{61}y^{66} - y^{66} \qquad (3.13)$$

The intermediate output levels using 1961 technology ($'Q^{66}$) to deliver the 1966 level and composition of final demand (y^{66}) are computed with equation (3.13) by multiplying the 1966 final demand vector by the inverse of 1961 (C^{61}) and deducting from this the actual final demand of 1966 (y^{66}). A similar computation is performed using 1966 technology ($Q^{66} = C^{66}y^{66} - y^{66}$). This is the difference between the actual GPV and final demand for that year. The results of the two computations indicate the changes in intermediate output levels arising out of the change in technology. This comparison is important for purposes of understanding various types of industrial specialization.

3.3.2 SUMMARY MEASURES OF STRUCTURAL CHANGE BASED ON INVERSE MATRICES

The procedures described above provide answers to the probable sources of structural change. A close scrutiny of these procedures would, however, reveal that we are in fact considering changes in matrix C. In a general sense, analysis of the changes in the elements of matrix C could be considered as reflecting structural change.

The earliest attempt to analyze structural change on the basis of the inverse matrix is found in a study by Rasmussen (1957) of the Danish economy. Since the number of elements in an inverse matrix is usually large he suggested some summary measures to analyze changes in its elements. In this study we apply Rasmussen's summary measures to the analysis of inverse matrices of the Canadian economy for 1961 and 1966.

The analysis of the elements of the inverse matrix C would reveal the structure of the economy as well as that of the industry. Let us denote the elements of C by c_{ij} [1)] and use the following formualtion.

The sum of the column elements of the inverse denoted by

$$\sum_{i=1}^{m} c_{ij} = C_{.j} \qquad (3.14)$$

shows the total input requirements for a unit increase in final demand for the j-th industry.

And similarly, the sum of the row elements:

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1) It has been shown (in equation 3.7) that C is an inverse matrix derived as a (DB) product. Since D is an industry by commodity matrix, and B is a commodity by industry matrix, the product is an industry by industry matrix; subscripts i and j used here should not be confused with the ones used earlier where i refers to commodities and j indicates industries.

$$\sum_{j=1}^{m} c_{ij} = C_{i.} \qquad (3.15)$$

reveals the increase in the output of industry i needed to cope with a unit increase in the final demand of all industries.

Rasmussen interprets the vector of averages:

$$\frac{1}{m} C_{.j} \quad (j = 1,\ldots,m) \qquad (3.16)$$

as an estimate of the direct and indirect increase in output to be supplied by an industry chosen at random, if the final demand for the products of industry j increases by one unit.

Another set of averages:

$$\frac{1}{m} C_{i.} \quad (i = 1,\ldots,m) \qquad (3.17)$$

has a similar interpretation.

Indices in (3.16) and (3.17) do not seem suitable for making inter-industry comparisons, so they are normalized by the overall average defined as:

$$\frac{1}{m^2} \sum_{j=1}^{m} \sum_{i=1}^{m} c_{ij} = \frac{1}{m^2} \sum_{j=1}^{m} C_{.j} = \frac{1}{m^2} \sum_{i=1}^{m} C_{i.} \qquad (3.18)$$

The following indices are, therefore, considered and used:

$$K_{.j} = \frac{\frac{1}{m} C_{.j}}{\frac{1}{m^2} \sum_{j=1}^{m} C_{.j}} \qquad (3.19)$$

$$K_{i.} = \frac{\frac{1}{m} C_{i.}}{\frac{1}{m^2} \sum_{i=1}^{m} C_{i.}} \quad (3.20)$$

Indices $K_{.j}$ and $K_{i.}$ are termed (by Rasmussen, 1957) as "index of power of dispersion" and "index of sensitivity of dispersion", respectively.[1)]

Since the average in (3.16) shows the requirements of inputs, if the final demand of industry j increases by one unit, $K_{.j} > 1$ can be interpreted to mean that the industry in question draws heavily on the rest of the system. In the same way, $K_{i.} > 1$ would indicate that industry i must increase its output more than others for a unit increase in final demand from the whole system.

Since the indices in equations (3.19) and (3.20) are based on the averaging principle, they are sensitive to extreme values and may give misleading results. To avoid this deficiency, coefficients of variation of the indices are defined as:

$$L_{.j} = \sqrt{\frac{\frac{1}{m-1} \sum_{i=1}^{m} \left(c_{ij} - \frac{1}{m} \sum_{i=1}^{m} c_{ij}\right)^2}{\frac{1}{m} \sum_{i=1}^{m} c_{ij}}} \quad (3.21)$$

1) These indices are analogous to Hirschman's (1958) backward and forward linkages, respectively. We return to the examination of these in chapter 6 of this study. See Hazari (1970) and Laumas (1975) for the application of these analogues.

$$L_{i.} = \sqrt{\frac{\frac{1}{m-1}\sum_{j=1}^{m}\left(c_{ij} - \frac{1}{m}\sum_{j=1}^{m} c_{ij}\right)^2}{\frac{1}{m}\sum_{j=1}^{m} c_{ij}}} \qquad (3.22)$$

$(i = 1,\ldots,m)$
$(j = 1,\ldots,m)$

A high $L_{.j}$ can be interpreted as showing that a particular industry draws heavily on one or a few sectors and a low $L_{.j}$ as an industry drawing evenly from other sectors. Similar interpretation applies to the $L_{i.}$'s.

CHAPTER 4

CHANGES IN THE STRUCTURE OF THE CANADIAN ECONOMY, 1961-66: DISCUSSION OF EMPIRICAL FINDINGS

In this chapter we discuss findings of an analysis of changes in the structure of the Canadian economy between 1961 and 1966. These are described on the basis of procedures I and II and the summary measures analyzing the inverse matrices. As explained in chapter 3, procedure I involves the scrutiny of changes in the GPV arising out of changes in the bill of final demand and changes in the coefficients themselves. Procedure II involves the analysis of changes in the intermediate output levels required to satisfy the fixed bill of final demand. Summary measures of structural change describe an inter-temporal change in technologies.

4.1 CHANGES IN THE GPV LEVELS: 1961-66

Changes in the GPV levels arising out of changes in the bill of final demand are obtained if we multiply the 1961 bill of final demand by the 1966 inverse matrix and compare this derived GPV of 1961 ($C^{66}y^{61}$) with the actual GPV of 1966 ($C^{66}y^{66}$). This comparison shows changes in GPV due solely to changes in final demand. And if we compare the derived 1961 GPV ($C^{66}y^{61}$) with the actual GPV in 1961 ($C^{61}y^{61}$), the comparison shows changes in GPV attributable solely to changes in coefficients.

Table 4.1 shows the total (direct and indirect) changes in GPV between 1961 and 1966 distributed by sources of change. It is evident that from 1961 to 1966 changes in the final demand resulted in a change of

Table 4.1 Causes of Change in Gross Production - 1961-1966 (in 000$ Current Prices)

	Gross Production		Change in Gross Production			Index of Change		
	1961 (1)	1966 (2)	Total (3)	Due to Final Demand Change (4)	Due to Coefficient Change (5)	Total (6)=2÷1	Due to Final Demand Change (7)=1+4÷1	Due to Coefficient Change (8)=1+5÷1
1. Agriculture	2,858,574	4,749,260	1,890,686	2,065,101	- 174,415	166.1	172.2	93.9
2. Forestry	821,368	1,073,622	252,254	336,170	- 83,916	130.7	140.9	89.8
3. Fishing	123,592	192,889	69,297	59,230	+ 10,067	156.0	147.9	108.1
4. Metal Mines	1,105,670	1,537,287	431,617	504,806	- 73,189	139.0	145.6	93.4
5. Coal	72,062	84,440	12,378	28,140	- 15,762	117.2	139.0	78.1
6. Petroleum & Gas Wells	804,512	1,407,396	602,884	578,200	+ 24,683	174.9	171.9	103.1
7. Non-metal Mines	273,364	433,963	166,599	158,600	+ 1,999	158.7	158.0	100.7
8. Meat Products	1,281,633	1,888,863	607,230	565,732	+ 41,498	147.4	144.1	103.2
9. Dairy Products	916,669	1,196,451	279,782	267,767	+ 12,015	130.5	129.2	101.3
10. Fish Products	187,561	312,297	124,736	108,291	+ 16,445	166.5	157.7	108.8
11. Grain Mills	565,542	807,756	242,214	293,569	- 51,355	142.8	151.9	90.9
12. Other Food & Soft Drinks	1,752,183	2,417,199	665,016	708,603	- 43,587	137.9	140.4	97.5
13. Alcoholic Beverages	453,515	628,212	174,697	178,110	- 3,413	138.5	139.3	99.2
14. Tobacco	334,992	438,842	103,850	99,188	+ 4,662	131.0	129.6	101.4
15. Rubber	339,502	570,400	230,898	226,389	+ 4,509	168.0	166.7	101.3
16. Leather	295,257	377,525	82,268	74,327	+ 7,941	127.9	125.2	102.7
17. Textiles	884,149	1,382,163	498,014	544,361	- 46,347	156.3	161.6	94.7
18. Clothing, Knitting	1,038,064	1,496,092	458,028	420,732	+ 37,296	144.1	140.5	103.6
19. Wood	1,059,689	1,621,328	561,639	530,330	+ 31,309	153.0	150.0	102.9
20. Furniture	366,267	622,465	256,198	241,753	+ 14,445	169.9	166.0	103.9
21. Pulp & Paper (Dummy)	1,044,197	1,422,288	378,091	442,110	- 64,019	136.2	142.3	93.9
22. Pulp-making	800,084	1,542,612	742,528	494,277	+ 248,251	192.8	161.8	131.0
23. Paper Making & Other Activity	1,279,089	1,695,972	416,883	501,693	- 84,810	132.6	139.2	93.4
24. Paper Converters	581,054	897,540	316,486	328,579	- 12,093	154.5	156.5	97.9
25. Printing & Publishing	874,780	1,231,433	356,653	496,137	- 139,484	140.8	156.7	84.0
26. Iron & Steel	1,034,201	1,687,655	653,454	766,658	- 113,204	163.2	174.1	89.0
27. Primary Non-Ferrous	1,714,121	2,655,728	941,607	889,805	+ 51,802	154.9	151.9	103.0
28. Metal Fabricating	1,554,318	2,858,528	1,304,210	1,370,336	- 66,126	183.9	188.1	95.7
29. Machinery	765,436	1,705,184	939,748	974,097	- 34,349	222.8	227.3	95.5
30. Motor Vehicles	944,994	2,282,734	1,337,740	1,214,320	+ 123,420	241.6	228.5	113.0
31. Truck Bodies & Trailers	49,978	127,981	78,003	78,159	- 155	256.1	256.4	99.7
32. Parts & Accessories	355,232	834,178	478,946	416,881	+ 62,065	234.8	217.3	117.5
33. Aircraft & Parts	364,761	556,588	191,827	198,157	- 6,330	152.6	154.3	98.3
34. Railroad Rolling Stock	68,267	185,102	116,835	120,626	- 3,791	271.1	276.7	94.4
35. Shipbuilding & Repairs	139,427	298,299	158,872	130,340	+ 28,532	213.9	193.5	120.0
36. Misc. Transport Equipment	22,538	87,431	64,893	66,837	- 1,944	387.9	396.5	91.4
37. Electrical Products	1,289,914	2,398,253	1,108,339	1,049,064	+ 59,275	185.9	181.3	104.5
38. Non-metallic Mining Products	696,802	1,156,941	460,139	471,876	- 11,737	166.0	167.7	98.3
39. Petroleum & Coal Products	1,242,351	1,537,116	294,765	448,606	- 153,841	123.7	136.1	87.6
40. Industrial Chemicals	498,868	802,921	304,053	282,422	+ 21,631	160.9	156.6	104.3
41. Chemical Products	998,817	1,493,055	494,238	549,513	- 55,275	149.5	155.0	94.5
42. Misc. Manufactures	648,603	1,067,847	419,239	365,954	+ 53,285	164.6	156.4	109.2
43. Repair Construction	1,456,083	1,954,543	498,460	595,199	- 96,739	134.2	140.9	93.3
44. Residential Construction	1,497,000	2,179,400	682,400	682,400	-	145.6	145.6	100.0
45. Non-residential Construction	1,790,708	3,296,502	1,505,794	1,505,794	-	184.1	184.1	100.0
46. Roads, Hyways & Airstrip Const.	556,936	946,399	389,463	389,463	-	169.9	169.9	100.0
47. Gas & Oil Facility Const.	470,049	499,709	29,660	29,660	-	106.3	106.3	100.0
48. Dams & Irrigation Projects	425,466	896,725	471,259	471,259	-	210.8	210.8	100.0
49. Railway, Telephones & Telegraph Const.	231,790	314,574	82,784	82,784	-	135.7	135.7	100.0
50. Other Engineering Construction	574,312	1,032,537	458,225	458,225	-	179.8	179.8	100.0

Table 4.1 Causes of Change in Gross Production - 1961-1966 (In 000$ Current Prices)

	Gross Production		Change in Gross Production			Index of Change		
	1961 (1)	1966 (2)	Total (3)	Due to Final Demand Change (4)	Due to Coefficient Change (5)	Total (6)=2÷1	Due to Final Demand Change (7)=1+4÷1	Due to Coefficient Change (8)=1+5÷1
51. Other Construction Activity	52,824	80,600	27,776	32,387	- 4,611	152.6	161.3	91.3
52. Air Transport	273,846	494,539	220,693	196,719	+ 23,974	180.6	171.8	108.7
53. Railway Transport	1,195,329	1,446,130	250,801	395,031	- 144,230	121.0	133.0	87.9
54. Pipelines	205,402	297,816	91,414	157,915	- 63,501	146.4	177.6	68.8
55. Urban Transit System	139,58[illegible]	182,551	43,967	41,033	+ 2,934	131.7	129.6	102.1
56. Water Transport	437,[illegible]30	551,824	114,494	115,622	- 1,128	126.2	126.4	99.7
57. Motor Transport & Other	1,103,271	1,692,877	589,606	498,848	+ 90,758	153.4	145.2	108.2
58. Storage	165,538	240,835	75,297	89,795	- 14,498	145.5	154.2	91.2
59. Radio & TV Broadcasting	110,589	192,379	81,790	83,720	- 1,930	173.9	175.7	98.2
60. Telephones & Telegraph	780,755	1,224,378	443,623	470,677	- 27,054	156.8	160.3	96.5
61. Post Office	210,512	290,250	79,738	98,931	- 19,193	137.9	147.0	90.9
62. Electric Power	878,177	1,243,847	365,670	386,032	- 20,362	141.6	143.9	97.6
63. Gas	144,780	235,404	90,624	83,069	+ 7,555	162.6	157.4	105.2
64. Water & Other	10,556	21,900	11,344	11,341	+ 3	207.5	207.4	100.0
65. Wholesale Trade	2,640,799	4,180,475	1,539,696	1,532,366	+ 7,330	158.3	158.0	100.2
66. Retail Trade	4,221,840	6,034,178	1,812,338	1,835,992	- 23,654	142.9	143.5	99.4
67. Finance, Insurance, Real Est.	4,313,462	6,426,029	2,112,567	2,208,933	- 96,366	149.0	151.2	97.8
68. Owner-Occupied Dwellings	2,471,700	3,395,200	923,500	923,500	-	137.4	137.4	100.0
69. Educational & Related Service	81,200	129,300	48,100	48,100	-	159.2	159.2	100.0
70. Health & Hospitals	618,014	961,108	343,094	343,072	+ 22	155.5	155.5	100.0
71. Hotels & Restaurants	1,668,280	2,254,518	586,238	611,956	- 25,718	135.1	136.7	98.4
72. Business Services	616,591	1,074,366	457,775	432,718	+ 25,057	174.2	170.2	104.0
73. Other Services	1,275,076	2,052,119	777,043	786,833	- 9,790	160.9	161.7	99.2
74. Transport Margins (Dummy)	1,730,147	2,135,965	405,818	465,633	- 59,815	123.4	126.9	96.5
75. Other (Dummy)	3,125,865	6,365,351	3,239,486	3,073,239	+ 166,247	203.6	198.3	105.3
	67,972,400	106,087,700	38,115,300	38,783,810	- 668,510	156.07	157.06	99.02

$38.8 billion in total output. Columns (3) to (5) indicate GPV change in absolute values, while columns (6) to (8) show the corresponding indices. An examination of columns (3) and (6) reveals a wide range in the changes in GPV for individual industries. The increased level of final demand does not affect all the 75 industries to the same extent. Highest absolute increases are observed in finance, insurance and real estate, retail trade, wholesale trade, agriculture, metal fabricating and non-residential construction. The highest indices of GPV change are noticed in miscellaneous transport equipment, motor vehicles, machinery, water and other utilities, railroad rolling stock, parts and accessories. These large increases in the index level can be traced back to the low level of gross production in 1961.

In columns (4) and (7), it is clear that overall gross production for 35 (out of 75) industries would have increased more if only final demand had changed between 1961 and 1966 and the coefficients had remained constant. For example, the index for metal fabricating would have been 188.1 rather than the total index of 183.9. On the other hand, of the remaining 40 industries which show a smaller change in final demand than the total, the index for pulp-making, for example, would have been 161.8 rather than 192.8. These differences are attributable to changing input and inverse coefficients between 1961 and 1966, shown as absolute figures in column (5) and as indices in column (8) of table 4.1.

The indices of GPV shown in column (8) of table 4.1 would have obtained if coefficients only had changed between 1961 and 1966, and final demand had remained constant over this period. An index of 100.0, for example in water and other utilities, reflects a neutral effect of coefficient or technological change between 1961 and 1966; an index of over 100.0 indicates an increase in GPV would have been required to deliver 1961 final demand. Therefore, an index of under 100.0 reflects savings in gross production requirements for meeting the same final demand. An examination of individual indices (col. 8) reveals that the largest negative impact of coefficient change on GPV between 1961 and 1966 occurs in the coal industry (an index of 78.1). The reduction of about 22 per cent can be interpreted as the result of changing interindustry relationships; technological progress would have made it possible to deliver the same 1961 final demand with less production in 1966 than in 1961. In contrast, the largest positive impact of changing coefficients is evident in pulp-making (an index of 131.0).

4.2 CHANGES IN INTERMEDIATE OUTPUT REQUIREMENTS, 1961-66

Changes in the intermediate output levels required to deliver a fixed bill of final demand have been computed on the basis of equation (3.13) of chapter 3. We use the 1966 bill of final demand (level and composition) and study changes in the intermediate output levels required to deliver this final demand bill with the 1961 and 1966 technologies. Results of these computations are shown in table 4.2. To facilitate interpretation of these results, we have grouped them by economic functional groups following Carter (1970). Within each group, industries are arranged in

TABLE 4.2 INTERMEDIATE OUTPUT REQUIREMENTS FOR DELIVERING 1966 TOTAL FINAL DEMAND WITH 1961 AND 1966 TECHNOLOGIES.

	Derived 1966 intermediate output levels with:		Changes in 1966 intermediate output levels.	
	1961 inverse (1)	1966 inverse (2)	1966-61 (3)	Per cent. (4)
I. General Industries:				
Utilities:				
(61) Post Office.	232,873	203,632	- 29,241	- 12.56
(62) Electric Power	688,308	647,475	- 40,833	- 5.93
(64) Water.	25,311	25,201	- 110	- 0.43
(63) Gas.	85,842	97,120	11,278	13.14
TOTAL:	1,032,334	973,428	- 58,906	- 5.71
Communications:				
(60) Telephones and Telegraph.	695,294	647,914	- 47,380	- 6.81
(59) Radio and T.V.	191,178	184,512	- 6,666	- 3.49
TOTAL:	886,472	832,426	- 54,046	- 6.09
Trade:				
(66) Retail Trade.	1,191,052	1,134,135	- 56,917	- 4.78
(65) Wholesale Trade.	2,113,807	2,123,630	9,823	0.46
TOTAL:	3,304,859	3,257,765	- 47,094	- 1.42
Services:				
(71) Hotels and Restaurants.	508,061	451,817	- 56,244	- 11.07
(67) Rinance, Insurance and Reasl Est.	2,975,607	2,799,382	-176,225	- 5.92

(73) Other services.	886,589	866,044	- 20,545	- 2.32
(70) Health and Hospitals.	1,031	1,062	31	2.94
(72) Business services.	857,530	894,687	37,157	4.33
TOTAL:	5,228,818	5,012,992	- 215,226	- 5.92
Transportation:				
(54) Pipelines	232,942	134,226	- 98,716	- 42.38
(53) Railway Transp.	1,435,018	1,229,051	-205,967	- 14.35
(56) Water Transp.	435,723	426,178	- 9,545	- 2.19
(57) Motor Transp.	1,223,782	1,330,413	106,631	8.71
(52) Air Transport.	249,694	289,495	39,801	15.94
(55) Urban Transit.	1,569	6,950	5,381	342.95
TOTAL:	3,578,728	3,416,313	-162,415	- 4.54
(39) Petroleum products.	1,220,662	964,196	-256,466	- 21.01
(5) Coal Mining.	215,193	186,091	- 29,012	- 13.52
(58) Storage.	219,545	196,189	- 23,356	- 10.64
II. Chemicals:				
(41) Chemical prod	1,125,098	1,024,777	-100,322	- 8.92
(40) Industrial chemicals.	800,079	836,176	36,097	4.51
III. Materials:				
(2) Forestry.	1,110,293	973,924	-136,369	- 12.28
(26) Iron and steel.	1,914,231	1,739,632	-174,599	- 9.12
(1) Agriculture.	3,114,864	2,854,138	-260,726	- 8.37
(38) Non-metallic mineral prod.	1,199,180	1,188,835	- 10,345	- 0.86
(15) Rubber.	502,146	501,561	- 584	- 0.12
(27) Primary non-ferrous.	1,681,443	1,760,131	78,688	4.68
(3) Fishing.	153,297	167,188	13,891	9.06

(20) Furniture.	110,056	134,013	23,957	21.76
(19) Wood.	1,007,550	1,056,101	48,551	48.19
TOTAL:	10,793,060	10,375,523	- 417,537	- 3.87
IV. Metal-working:				
(36) Misc. transp. equipment.	10,806	7,201	- 3,604	- 33.35
(34) Railway rolling stock.	74,947	66,368	- 8,579	- 11.45
(29) Machinery.	1,049,770	974,222	- 75,548	- 7.18
(28) Metal fabricating.	2,776,431	2,671,271	- 105,160	- 3.79
(33) Aircrafts and parts.	187,960	182,153	- 5,806	- 3.09
(31) Trucks, bodies and trailers.	18,890	18,425	- 465	- 2.46
(37) Electrical products.	1,342,493	1,454,358	111,865	8.33
(32) Parts and accessories.	1,164,363	1,290,387	126,024	10.82
(35) Shipbuilding and repairs.	55,775	98,927	43,152	77.37
(30) Motor vehicles.	143,976	398,585	254,609	176.84
TOTAL:	6,825,411	7,161,897	336,486	4.93
V. All other:				
(25) Printing and publishing.	1,298,307	1,010,516	- 287,701	- 22.17
(23) Paper making and other.	822,242	677,643	- 144,599	- 17.59
(51) Other construction.	49,891	42,190	- 7,701	- 15.44
(4) Metal mines.	996,462	871,235	- 125,227	- 13.52
(11) Grain mills.	659,217	580,624	0 78,592	- 11.92
(43) Repair construction.	1,548,867	1,404,927	- 143,940	- 9.29
(13) Alcoholic Beverages.	77,362	71,322	- 6,041	- 7.81

(21) Pulp and Paper	1,521,714	1,422,288	- 99,426	- 6.53
(12) Other food and soft drinks.	797,064	749,626	- 47,438	- 5.95
(17) Textiles.	1,440,954	1,375,045	- 65,909	- 4.57
(24) Paper converters.	816,784	800,117	- 16,666	- 2.04
(6) Petroleum and gas wells.	1,236,236	1,246,913	10,667	0.86
(7) Non-metal mining.	246,927	252,706	5,779	2.34
(14) Tobacco.	100,347	106,142	5,795	5.78
(9) Dairy products.	280,018	301,149	21,131	7.55
(16) Leather.	102,795	113,650	10,855	10.56
(8) Meat products.	551,156	619,481	68,325	12.40
(42) Misc. manufactures.	684,388	775,688	91,300	13.34
(18) Clothing.	198,881	254,975	56,094	28.20
(10) Fish products.	49,239	70,723	21,483	43.63
(22) Pulp-making.	680,972	1,026,627	345,655	50.76
TOTAL:	14,159,823	13,773,587	-386,236	- 2.73

order of the rank of percentage change. Ranking is done with the highest negative rate as rank 1, which represents the industry with most rapidly declining intermediate output requirements.

The figures in column (1) and column (2) show a slight decline over time: the total volume of intermediate outputs (inputs) required to satisfy the 1966 bill of final demand[1)] tends to be smaller with newer than with older technology, measured by inverse coefficients.[2)] This overall tendency, however, is not shared by all industries within each group. At the group level, requirements from all groups but metal-working have been declining. Metal-working inputs rise as the complexity of these products increases and as specialization within metal-working grows. Material inputs, on the other hand, decline as the size and weight of many different equipment items decrease, as waste of materials is reduced, and as cheaper materials are substituted for more expensive one.

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1) Caution is desirable in interpreting the notion of the "same final product". The output of an industry, say food products, is stipulated as qualitatively the same between 1961 and 1966. Reality may, however, preclude this from happening since the industry's product-mix may change over time. We do not attempt to compensate or adjust for the effect of changing quality or product-mix on direct and indirect requirements in this study.

2) Contrasting evidence in this regard is found in the U.S. In studying structural change over time in the American economy, using similar methodology, Carter (1970) found that "... dollar volume of intermediate inputs (in constant prices) remains quite stable, growing slightly over time - to be a little greater with newer, than with older, techniques of production". To resolve this paradox she puts forward the view that an increased volume of intermediate inputs means an increase in specialization. It represents a change in the division of labour among establishments, but does not in itself imply a deterioration of technology. The later technologies use slightly more intermediate inputs but less primary inputs.

Requirements from certain individual sectors within each of the broad industrial groupings are susceptible to persistent changes. It is easy to single out some more dramatic cases. These are listed in table 4.3. This table shows those sectors that gain or lose importance most rapidly as a result of structural change.

4.3 STRUCTURAL CHANGES: SUMMARY MEASURES BASED ON THE INVERSE MATRIX

Identification of causes of change in GPV levels arising out of the changing bill of final demand or changing coefficients is a fruitful endeavour in itself. However, the more pertinent aspect to examine is the inter-temporal change in technology. The effects of changing technology and organization of production can best be understood by studying the composition of interindustry transactions. When the methods of production change, the interdependence of individual supplying industries changes accordingly.

It would appear from the discussion in sections 4.1 and 4.2 that, while analyzing change in the GPV levels, we are in fact considering changes in the elements of the inverse matrix C. In this section we present an independent analysis of structural change on the basis of the summary measures formulated in equation (3.19) to (3.22) in chapter 3.

The indices $K_{.j}$ and $K_{i.}$ and their corresponding measures of variation $L_{.j}$ and $L_{i.}$, as they are applied to the inverse matric C, deal with the total (direct and indirect) requirements of the system to supply a given

Table:4.3

Sectors Whose Intermediate Deliveries Are Most Affected By Structural Change (% Change)

I. Gaining:

(55)	Urban Transit System	342.95
(30)	Motor Vehicles	176.84
(35)	Shipbuilding & Repairs	77.37
(22)	Pulp-making	50.76
(19)	Wood	48.19
(10)	Fish Products	43.63
(18)	Clothing & Knitting	28.20
(20)	Furniture	21.76
(52)	Air Transport	15.94
(63)	Gas	13.14

II. Declining:

(54)	Pipelines	- 42.38
(36)	Mics. Transport Equipment	- 33.35
(25)	Printing & Publishing	- 22.17
(39)	Petroleum Products	- 21.01
(23)	Paper making & other	- 17.59
(51)	Other Construction	- 15.44
(53)	Railway Transport	- 14.35
(5)	Coal Mining	- 13.52
(2)	Forestry	- 12.28

bill of final demand. It may be argued, however, that it is the <u>indirect effects</u> that are more relevant for understanding the sectoral interdependence of an economic system. Hence, matrix (C - I), where I is an identity matrix, is considered. We have incorporated this modification into our analysis, and indices $'K_{.j}$, $'K_{i.}$ and the corresponding variation measures, $'L_{.j}$ and $'L_{i.}$, have been utilized. Their interpretation is similar to the measures used for analyzing matrix C alone. The only difference is that the measures relating to (C - I) capture indirect effects only.

It may also be argued that, although the indirect effects are interesting, a more important feature in studying interdependence of the productive structure is the indirect effects on other industries exclusive of the industry considered -- disregarding the "feedback effects" on the industry itself. This reasoning leads to a consideration of the matrix $(C - \hat{c})$, where $\hat{c}$ is the diagonal matrix showing the c_{ii} elements of the original inverse matrix on the main diagonal. Indices similar to the earlier ones have been calculated and analyzed. These are $''K_{.j}$, $''K_{i.}$, $''L_{.j}$ and $''L_{i.}$.

The three alternative indices of power and sensitivity of dispersion as well as their corresponding sets of related measures of "variance" for these indices have been calculated for the Canadian economy for the years 1961 and 1966 (Tables 4.4 and 4.5). The resulting estimates can, to the extent that the two years compared turn out to involve different indices, be regarded as summary measures of structural change. The estimated indices are discussed below.

TABLE [illegible]. Indices of Power & Sensitivity of Dispersion, Canada

Industries	Indices of Sensitivity of Dispersion						Indices of Power of Dispersion					
	1966			1961			1966			1961		
	$K_{i.}$	$'K_{i.}$	$''K_{i.}$	$K_{i.}$	$'K_{i.}$	$''K_{i.}$	$K_{.j}$	$'K_{.j}$	$''K_{.j}$	$K_{.j}$	$'K_{.j}$	$''K_{.j}$
1. Agriculture	1.90	2.73	2.85	2.10	3.09	3.22	0.87	0.76	0.74	0.93	0.87	0.84
2. Forestry	1.20	1.39	1.39	1.31	1.59	1.60	0.94	0.84	0.84	0.97	0.94	0.89
3. Fishing	0.73	0.49	0.49	0.73	0.48	0.49	0.88	0.77	0.80	0.81	0.64	0.66
4. Metal Mines	1.11	1.20	1.23	1.21	1.41	1.51	0.80	0.63	0.66	0.71	0.45	0.49
5. Coal	0.67	0.38	0.39	0.69	0.42	0.45	0.80	0.62	0.66	0.75	0.53	0.56
6. Petroleum & Gas Wells	1.53	2.02	2.13	1.48	1.91	2.01	0.77	0.57	0.57	0.81	0.64	0.65
7. Non-metal Mines	0.69	0.40	0.43	0.68	0.40	0.42	0.85	0.72	0.77	0.84	0.69	0.74
8. Meat Product	0.78	0.58	0.49	0.75	0.53	0.42	1.30	1.57	1.54	1.34	1.65	1.62
9. Dairy Products	0.63	0.30	0.20	0.60	0.24	0.19	1.26	1.50	1.49	1.27	1.51	1.55
10. Fish Products	0.51	0.08	0.06	0.51	0.08	0.05	1.19	1.36	1.45	1.14	1.26	1.31
11. Grain Mills	0.75	0.52	0.45	0.78	0.59	0.52	1.36	1.63	1.69	1.32	1.62	1.62
12. Other Food & Soft Drinks	0.88	0.77	0.69	0.87	0.76	0.68	1.14	1.27	1.23	1.13	1.25	1.21
13. Alcoholic Beverages	0.53	0.10	0.08	0.53	0.11	0.08	0.99	0.99	1.04	0.98	0.97	1.00
14. Tobacco	0.63	0.28	0.01	0.61	0.26	0.00	1.27	1.51	1.31	1.29	1.55	1.58
15. Rubber	0.89	0.79	0.82	0.86	0.74	0.72	1.04	1.07	1.12	1.01	1.02	1.07
16. Leather	0.64	0.31	0.07	0.62	0.29	0.06	1.19	1.36	1.20	1.19	1.36	1.22
17. Textiles	1.50	1.96	1.66	1.53	2.01	1.72	1.14	1.27	0.92	1.10	1.19	0.94
18. Clothing, Knitting	0.63	0.30	0.21	0.58	0.21	0.15	1.17	1.32	1.30	1.15	1.29	1.30
19. Wood	1.08	1.15	1.10	1.05	1.09	1.07	1.10	1.20	1.16	1.12	1.23	1.18
20. Furniture	0.56	0.16	0.15	0.54	0.13	0.12	1.07	1.14	1.19	1.08	1.15	1.21
21. Pulp & Paper (Dummy)	1.50	1.95	2.09	1.54	2.02	2.17	0.72	0.47	0.49	0.69	0.41	0.43
22. Pulp-making	1.16	1.31	1.40	0.93	0.87	0.93	1.32	1.61	1.73	1.35	1.66	1.78
23. Paper Making & Other Activity	1.12	1.23	1.29	1.22	1.42	1.49	1.59	2.14	2.26	1.44	1.84	1.94
24. Paper Converters	1.02	1.09	1.05	1.02	1.04	1.04	1.34	1.66	1.71	1.34	1.64	1.68
25. Printing & Publishing	1.22	1.41	1.42	1.40	1.78	1.81	1.04	1.08	1.07	1.01	1.02	1.00
26. Iron & Steel	2.03	2.98	3.05	2.05	3.00	3.06	1.03	1.07	0.99	1.04	1.09	0.99
27. Primary Non-Ferrous	1.79	2.52	2.13	1.74	2.40	2.04	1.37	1.70	1.25	1.28	1.54	1.11
28. Metal Fabricating	2.19	3.25	3.35	2.20	3.28	3.39	1.09	1.17	1.11	1.10	1.18	1.13
29. Machinery	1.17	1.33	1.32	1.18	1.35	1.35	1.08	1.15	1.13	1.05	1.09	1.07
30. Motor Vehicles	0.69	0.41	0.30	0.56	0.17	0.14	1.39	1.74	1.74	1.28	1.53	1.50
31. Truck Bodies & Trailers	0.49	0.02	0.02	0.48	0.02	0.02	1.15	1.28	1.39	1.18	1.34	1.44
32. Parts & Accessories	1.17	1.33	1.25	1.11	1.22	1.12	1.18	1.34	1.26	1.15	1.29	1.20
33. Aircraft & Parts	0.67	0.36	0.20	0.67	0.37	0.17	1.06	1.12	1.01	1.04	1.08	0.94
34. Railroad Rolling Stock	0.58	0.19	0.09	0.59	0.23	0.09	1.21	1.40	1.36	1.14	1.27	1.21
35. Shipbuilding & Repairs	0.65	0.32	0.29	0.57	0.18	0.14	0.99	0.98	1.00	0.92	0.85	1.21
36. Misc. Transport Equipment	0.48	0.01	0.01	0.46	0.02	0.02	1.10	1.19	1.27	1.10	1.13	1.27
37. Electrical Products	1.45	1.86	1.79	1.36	1.69	1.62	1.13	1.25	1.15	1.10	1.20	1.09
38. Non-metallic Mining Products	1.14	1.27	1.21	1.10	1.20	1.17	1.00	1.02	0.94	1.02	1.05	0.98
39. Petroleum & Coal Products	1.30	1.57	1.67	1.44	1.85	1.96	1.17	1.32	1.41	1.37	1.26	1.33
40. Industrial Chemicals	1.26	1.49	1.43	1.21	1.42	1.40	1.00	1.00	0.96	0.97	0.94	0.90
41. Chemical Products	1.28	1.52	1.51	1.32	1.62	1.61	1.19	1.35	1.34	1.17	1.32	1.30
42. Misc. Manufactures	1.03	1.06	1.09	0.96	0.92	0.94	1.06	1.12	1.14	1.06	1.12	1.15
43. Repair Construction	1.31	1.59	1.70	1.41	1.73	1.71	0.82	0.86	0.71	0.80	0.80	0.85
44. Residential Construction	0.48	—	—	0.47	—	—	1.02	1.05	1.12	1.09	1.17	1.25
45. Non-residential Construction	0.48	—	—	0.47	—	—	1.06	1.11	1.19	1.13	1.24	1.33
46. Roads, Hyways & Airstrip Const.	0.48	—	—	0.47	—	—	0.99	—	1.06	1.07	1.13	1.21
47. Gas & Oil Facility Const.	0.48	—	—	0.47	—	—	1.33	1.15	1.27	1.11	1.02	1.31
48. Dams & Irrigation Projects	0.48	—	—	0.47	—	—	1.10	1.19	1.29	1.13	1.25	1.35
49. Railway, Telephones & Telegraph Const.	0.48	—	—	0.47	—	—	1.14	1.27	[illegible]	1.10	1.31	1.41
50. Other Engineering Construction	0.48	—	—	0.47	—	—	1.15	1.28	[illegible]	1.20	[illegible]	[illegible]

TABLE 4.4. Indices of Power & Sensitivity of Dispersion, Canada - concluded

Industries	Indices of Sensitivity of Dispersion						Indices of Power of Dispersion					
	1966			1961			1966			1961		
	$K_{i.}$	$^*K_{i.}$	$^{**}K_{i.}$	$K_{i.}$	$^*K_{i.}$	$^{**}K_{i.}$	$K_{.j}$	$^*K_{.j}$	$^{**}K_{.j}$	$K_{.j}$	$^*K_{.j}$	$^{**}K_{.j}$
51. Other Construction Activity	0.51	0.06	0.06	0.51	0.07	0.07	0.77	0.56	0.61	0.78	0.58	0.63
52. Air Transport	0.71	0.46	0.46	0.69	0.41	0.41	0.89	0.78	0.81	0.90	0.82	0.84
53. Railway Transport	1.41	1.79	1.90	1.51	1.96	2.08	0.77	0.56	0.57	0.77	0.55	0.57
54. Pipelines	0.59	0.21	0.22	0.68	0.39	0.37	0.61	0.26	0.26	0.65	0.35	0.32
55. Urban Transit System	0.48	0.00	0.01	0.47	0.00	0.00	0.62	0.28	0.30	0.64	0.32	0.34
56. Water Transport	0.91	0.82	0.60	0.92	0.84	0.59	0.67	0.76	0.53	0.94	0.89	0.64
57. Motor Transport & Other	1.52	1.99	2.07	1.39	1.74	1.82	0.82	0.66	0.64	0.81	0.63	0.64
58. Storage	0.58	0.20	0.21	0.59	0.23	0.23	0.75	0.53	0.56	0.75	0.53	0.55
59. Radio & TV Broadcasting	0.62	0.27	0.26	0.62	0.28	0.26	1.01	1.01	1.05	1.17	1.33	1.39
60. Telephones & Telgraph	0.93	0.95	1.02	0.98	0.97	1.03	0.61	0.26	0.23	0.62	0.29	0.30
61. Post Office	0.58	0.20	0.20	0.59	0.22	0.22	0.77	0.56	0.59	0.77	0.56	0.58
62. Electric Power	1.03	1.06	1.12	1.06	1.11	1.18	0.60	0.24	0.24	0.61	0.25	0.25
63. Gas	0.55	0.13	0.14	0.54	0.13	0.14	0.58	0.20	0.22	0.65	0.34	0.36
64. Water & Other	0.50	0.04	0.05	0.49	0.04	0.04	1.02	1.03	1.11	0.94	0.89	0.95
65. Wholesale Trade	2.00	2.92	3.11	1.89	2.69	2.86	0.80	0.62	0.65	0.83	0.69	0.70
66. Retail Trade	1.24	1.47	1.56	1.24	1.46	1.56	1.79	0.60	0.63	0.77	0.56	0.59
67. Finance, Insurance, Real Est.	2.25	3.39	3.54	2.35	3.59	3.74	0.71	0.45	0.38	0.71	0.44	0.37
68. Owner-Occupied Dwellings	0.48	—	—	0.47	—	—	0.59	0.21	0.23	0.60	0.24	0.27
69. Educational & Related Service	0.48	—	—	0.47	—	—	0.83	0.69	0.73	0.84	0.69	0.74
70. Health & Hospitals	0.48	0.01	0.01	0.47	0.00	0.00	0.73	0.48	0.52	0.75	0.52	0.56
71. Hotels & Restaurants	0.80	0.61	0.65	0.83	0.68	0.72	0.92	0.84	0.90	0.96	0.93	0.99
72. Business Services	1.10	1.19	1.24	1.09	1.17	1.22	0.67	0.37	0.36	0.66	0.36	0.36
73. Other Services	1.25	1.48	1.55	1.27	1.52	1.58	0.82	0.65	0.66	0.83	0.63	0.67
74. Transport Margins (Dummy)	1.56	2.08	2.22	1.53	2.00	2.15	1.28	1.53	1.63	1.27	1.51	1.61
75. Other (Dummy)	4.43	7.55	8.00	4.23	7.15	7.57	1.37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

4.3.1 DISCUSSION OF RESULTS

In table 4.4 indices of power and sensitivity of dispersion for both 1961 and 1966 are presented. Considering the Indices of sensitivity of dispersion ($K_{i.}$) first, we notice that industry no. 67 (Finance, insurance and real estate) shows by far the highest index -- 2.36 in 1961 -- followed by metal fabricating (industry no. 28) and agriculture (no. 1) with indices of 2.20 and 2.10, respectively, in the same year. These high index values indicate that the system of industries as a whole draws heavily on the industries in question. The lowest index of 0.47 is shown by health and hospitals (no. 70), followed by urban transit systems (no. 55) with an index of 0.47, and miscellaneous transport equipment (no. 36) with an index of 0.48 in the year 1961. These low indices imply that these industries are little affected by a general increase in final demand.

In 1966, as in 1961, finance, insurance and real estate (no. 67) and metal fabricating (no. 28) have the highest and second highest indices of 2.25 and 2.18, respectively. However, the third highest place in 1966 is taken by iron and steel (no. 26) with an index of 2.03. Almost the same picture holds in respect of the lowest indices. Health and hospitals (no. 70) with an index of 0.48 and miscellaneous transport equipment (no. 36), also with an index of 0.48, are the lowest in 1966, just as they were in 1961.

Considering the indices of power of dispersion ($K_{.j}$), it appears that in 1961 papermaking (no. 23), petroleum and coal products (no. 39) and pulpmaking (no. 22) have by far the largest indices -- 1.44, 1.37 and 1.35, respectively. In 1966, papermaking (no. 23) occupies the same place as in 1961, with an index of 1.59. However, the second and third largest in 1966 are different: primary non-ferrous metals (no. 27) with an index of 1.37 and grain mills (no. 11) with 1.36 respectively. The converse is also true for owner-occupied dwellings (no. 68), electric power (no. 62), and urban transit systems (no. 55), with the low indices of 0.60, 0.61 and 0.64, respectively, in 1961. In 1966, however, the lowest index of 0.58 is that of gas (no. 63), whereas the next lowest are owner-occupied dwellings (no. 68) and electric power (no. 62), with indices of 0.59 and 0.60, respectively. These industries seem to influence the systems of industries to a relatively small extent.

If, however, the influence of a certain industry on other industries (excluding itself) is studied, the indices "$K_{i.}$ and "$K_{.j}$ seem most relevant. These indices indicate wide variations for each of the years studied. However, when "$K_{i.}$ and "$K_{.j}$ are compared between 1961 and 1966 the pattern of variation is smaller. In respect of "$K_{i.}$, finance, insurance and real estate (no. 67) has the highest index of 3.74 in 1961, followed by metal fabricating (no. 28) and agriculture (no. 1) having indices of 3.38 and 3.22, respectively. In 1966, the two highest indices belong to the same industries as in 1961, with indices of 3.54 and 3.35, respectively. However, the third highest index of 3.11 is for wholesale trade (no. 65). The lowest index of 0.01 is obtained for health and hospitals (no. 70), both in 1961 and 1966.

Correspondingly, the highest index of power of dispersion "$K_{.j}$ in 1961 is 1.94 for papermaking (no. 23), followed by pulpmaking (no. 22) with an index of 1.78, and meat products (no. 8) with 1.62. In 1966, industries with the highest indices are papermaking (no. 23) with an index of 2.26, motor vehicles (no. 30) having an index of 1.73, and meat products (no. 8) with an index of 1.54. Compared to 1961, the second place in 1968 belongs to motor vehicles (no. 30) as against pulpmaking (no. 22) in the former year. The lowest indices in 1961 are those of electric power (no. 62), owner-occupied dwellings (no. 68), and pipelines (no. 54), with indices of 0.25, 0.27, and 0.32, respectively, whereas in 1966 the lowest indices are those of gas (no. 63) with an index of 0.22, electric power (no. 62) with an index of 0.24, and pipelines (no. 54) with an index of 0.26.

In table 4.5 related indices of variance, as defined, are shown. With a view to highlighting the importance of interrelations between industries and changes therein, it is considered relevant to disregard the direct and also the "feedback" effects for a certain industry on itself. Therefore, we examine the indices "$L_{i.}$ and "$L_{.j}$ only.

Considering indices "$L_{.j}$, it is noticed that on the whole, both in 1961 and 1966, the individual industries seem to draw rather uniformly on the system. Certain divergences are, however, apparent. In 1961, the owner-occupied dwellings industry (no. 68) has the highest index of variance of 4.35, followed by petroleum and coal products (no. 39) with an index of 3.88. In 1966, the highest index of 4.77 is for owner-occupied dwellings (no. 68) followed by an index of 4.09 for petroleum and coal products

TABLE [illegible]. Measures Of Variance Of Indices Of Power & Sensitivity Of Dispersion, Canada

Industries	1966			1961			1966			1961		
	$L_{i.}$	$'L_{i.}$	$''L_{i.}$	$L_{i.}$	$'L_{i.}$	$''L_{i.}$	$L_{.j}$	$'L_{.j}$	$''L_{.j}$	$L_{.j}$	$'L_{.j}$	$''L_{.j}$
1. Agriculture	3.14	2.95	3.02	[illegible].01	2.83	2.91	5.07	1.63	1.69	4.85	1.72	1.70
2. Forestry	4.05	2.72	2.87	4.89	2.95	3.12	4.90	2.10	2.17	4.78	2.05	2.09
3. Fishing	6.29	7.32	7.71	6.33	7.46	7.91	4.80	1.46	1.51	5.19	1.40	1.44
4. Metal Mines	4.03	2.99	3.02	3.70	2.72	2.73	5.20	1.59	1.93	5.78	1.72	1.75
5. Coal	6.14	1.23	1.27	5.89	1.20	1.22	5.22	2.19	2.22	5.49	2.04	2.06
6. Petroleum & Gas Wells	3.25	2.58	2.64	3.25	2.42	2.47	5.62	2.72	2.89	5.33	2.65	2.80
7. Non-metal Mines	6.00	1.44	1.47	6.01	1.54	1.56	4.88	1.87	1.89	4.93	1.74	1.76
8. Meat Products	6.02	2.49	2.14	6.26	2.81	2.46	4.23	3.64	3.92	4.09	3.43	3.69
9. Dairy Products	7.26	3.21	1.51	7.30	2.95	2.54	4.07	3.11	3.31	4.02	3.40	3.55
10. Fish Products	8.09	2.62	2.77	8.28	4.32	2.24	3.78	2.70	2.72	4.09	2.91	3.01
11. Grain Mills	6.11	2.61	2.50	5.88	2.55	2.53	3.56	2.08	2.17	3.72	2.38	2.51
12. Other Food & Soft Drinks	5.31	1.99	1.80	5.39	2.11	1.93	4.14	1.68	1.67	4.15	1.69	1.69
13. Alcoholic Beverages	9.01	2.41	0.83	7.99	2.62	0.87	4.29	1.67	1.72	4.34	1.63	1.68
14. Tobacco	8.64	8.59	0.62	8.63	8.54	0.89	4.43	2.66	2.68	4.32	2.74	2.86
15. Rubber	4.75	1.07	1.09	4.85	1.13	1.16	4.17	1.88	1.93	4.24	1.90	1.96
16. Leather	8.19	6.80	1.79	8.21	6.82	1.82	4.39	1.91	1.53	4.33	1.89	1.54
17. Textiles	4.23	2.87	2.89	4.13	2.82	2.87	5.26	2.97	1.58	5.39	3.04	1.57
18. Clothing, Knitting	7.26	3.37	2.36	7.58	3.35	2.14	4.35	3.33	3.57	4.32	3.50	3.70
19. Wood	4.35	1.63	1.59	4.50	1.68	1.57	4.38	2.49	2.63	4.38	2.58	2.74
20. Furniture	7.50	1.73	1.49	7.74	2.07	1.82	3.98	1.59	1.62	3.93	1.56	1.60
21. Pulp & Paper (Dummy)	3.65	3.62	3.63	3.49	3.35	3.37	5.75	1.92	1.95	5.98	1.89	1.92
22. Pulp-making	4.15	3.78	3.80	4.70	3.53	3.55	3.68	3.13	3.20	3.55	2.97	2.98
23. Paper Making & Other Activity	3.97	2.33	2.40	3.69	2.28	2.33	3.51	3.36	3.41	3.71	3.49	3.56
24. Paper Converters	4.29	0.96	0.92	4.30	1.02	0.96	3.49	2.10	2.17	3.56	2.29	2.39
25. Printing & Publishing	3.67	0.93	0.90	3.18	0.96	0.96	4.39	2.10	2.20	5.54	2.20	2.31
26. Iron & Steel	2.52	1.49	1.53	2.51	1.48	1.53	4.61	1.77	1.65	4.63	1.91	1.80
27. Primary Non-Ferrous	3.65	2.00	1.25	3.69	1.99	1.25	4.94	3.41	3.15	5.17	3.69	3.64
28. Metal Fabricating	2.22	1.00	1.01	2.19	1.02	1.04	4.46	2.31	2.41	4.41	2.37	2.49
29. Machinery	3.84	0.85	0.73	3.78	0.79	0.66	4.30	1.93	1.99	4.38	1.91	1.97
30. Motor Vehicles	6.81	2.88	1.51	7.55	1.95	1.33	3.68	2.49	2.63	3.62	2.51	2.56
31. Truck Bodies & Trailers	8.45	1.01	1.04	8.47	1.19	1.22	3.66	1.65	1.65	3.54	1.61	1.61
32. Parts & Accessories	4.45	3.10	3.37	4.64	3.13	3.41	4.22	2.10	2.13	4.29	2.03	2.01
33. Aircraft & Parts	7.38	4.35	2.30	7.52	4.87	2.32	4.66	1.94	1.73	4.34	2.07	1.67
34. Railroad Rolling Stock	7.97	4.79	1.70	7.98	5.37	1.76	3.88	1.75	1.81	4.22	1.85	1.84
35. Shipbuilding & Repairs	6.72	2.87	3.06	7.63	3.39	3.22	4.44	1.89	1.97	4.76	1.97	2.05
36. Misc. Transport Equipment	8.55	2.53	1.59	8.51	1.92	1.29	2.79	1.43	1.49	3.77	1.46	1.45
37. Electrical Products	3.49	1.58	1.54	3.65	1.60	1.55	4.44	2.03	1.94	4.47	1.93	1.79
38. Non-metallic Mining Products	4.18	1.62	1.56	4.18	1.56	1.54	4.72	1.76	1.60	4.65	1.59	1.52
39. Petroleum & Coal Products	2.18	0.71	0.73	2.86	0.70	0.72	4.26	4.05	4.09	4.25	3.82	3.89
40. Industrial Chemicals	3.70	1.33	1.32	3.79	1.39	1.38	4.62	1.57	1.48	4.72	1.57	1.47
41. Chemical Products	3.58	0.82	0.69	3.45	0.79	0.66	3.95	1.69	1.72	4.00	1.69	1.71
42. Misc. Manufactures	4.21	0.77	0.71	4.46	0.79	0.75	4.15	1.51	1.56	4.09	1.53	1.53
43. Repair Construction	3.15	0.96	0.97	2.91	0.90	0.90	5.03	1.52	1.54	4.61	1.42	1.44
44. Residential Construction	8.66	—	—	8.66	—	—	4.07	1.71	1.71	3.81	1.63	1.55
45. Non-residential Construction	8.66	—	—	8.66	—	—	3.94	1.68	1.69	3.69	1.62	1.62
46. Roads, Hyways & Airstrip Const.	8.66	—	—	8.66	—	—	4.18	1.66	1.66	3.88	1.56	1.56
47. Gas & Oil Facility Const.	9.66	—	—	8.66	—	—	3.96	2.2[illegible]	2.2[illegible]	3.83	2.2[illegible]	2.2[illegible]
48. Dams & Irrigation Projects	8.66	—	—	8.66	—	—	3.8[illegible]	1.3[illegible]	1.3[illegible]	[illegible]	1.2[illegible]	1.2[illegible]
49. Railway, Telephones & Telegraph Const.	8.66	—	—	9.66	—	—	3.74	2.05	2.04	[illegible]	1.91	1.91
50. Other Engineering Construction	5.66	—	—	8.66	—	—	[illegible]	[illegible]	[illegible]	[illegible]	1.7[illegible]	1.7[illegible]

[illegible] 4.5. Measures Of Variance Of Indices Of Power & Sensitivity Of Dispersion, Canada — Continued

Industries	1966			1961			1966			1961		
	$L_{i.}$	$'L_{i.}$	$''L_{i.}$	$L_{i.}$	$'L_{i.}$	$''L_{i.}$	$L_{.j}$	$'L_{.j}$	$''L_{.j}$	$L_{.j}$	$'L_{.j}$	$''L_{.j}$
51. Other Construction Activity	8.12	0.93	0.95	8.02	0.71	0.73	5.34	1.83	1.84	5.26	1.83	1.83
52. Air Transport	5.90	1.34	1.37	6.13	0.15	1.55	4.81	1.83	1.94	4.74	1.88	1.94
53. Railway Transport	3.27	2.22	2.26	3.11	2.22	2.25	5.52	1.91	1.99	5.51	2.03	2.15
54. Pipelines	7.09	2.04	2.13	6.35	2.03	2.05	6.85	2.26	2.36	6.58	2.63	2.77
55. Urban Transit System	8.57	0.65	0.66	8.64	0.65	0.66	6.60	1.62	1.62	6.28	1.69	1.69
56. Water Transport	5.86	2.96	1.83	5.93	3.16	1.63	6.07	3.14	1.79	5.77	3.07	1.86
57. Motor Transport & Other	3.07	1.77	1.82	3.22	1.75	1.79	5.37	1.77	1.78	5.31	1.72	1.78
58. Storage	7.25	1.33	1.34	6.97	1.55	1.60	5.54	1.86	1.90	5.53	1.79	1.84
59. Radio & TV Broadcasting	6.87	1.27	0.99	6.35	1.35	1.04	4.41	2.69	2.73	3.35	2.46	2.53
60. Telephones & Telegraph	4.22	1.12	1.12	4.16	0.97	0.98	6.73	2.13	2.17	6.58	2.00	2.04
61. Post Office	7.16	0.88	0.83	7.06	0.98	0.91	5.48	2.51	2.57	5.47	2.56	2.63
62. Electric Power	4.02	0.71	0.73	3.89	0.69	0.71	6.95	2.25	2.36	6.85	2.42	2.53
63. Gas	7.54	0.78	0.79	7.57	0.83	0.83	7.08	2.40	2.40	6.30	2.30	2.30
64. Water & Other	8.26	1.04	1.06	8.31	0.69	0.71	4.14	2.07	2.07	4.43	2.04	2.05
65. Wholesale Trade	2.05	0.48	0.49	2.17	0.50	0.52	5.27	1.99	2.06	5.07	1.86	1.92
66. Retail Trade	3.32	0.69	0.70	3.30	0.67	0.68	5.32	1.95	2.00	5.42	1.89	1.94
67. Finance, Insurance, Real Est.	1.97	0.53	0.54	1.89	0.51	0.52	6.39	2.51	2.31	6.43	2.55	2.26
68. Owner-Occupied Dwellings	8.66	—	—	8.66	—	—	7.04	4.77	4.77	6.84	4.35	4.35
69. Educational & Related Service	8.66	—	—	8.66	—	—	5.05	2.68	2.68	4.98	2.61	2.61
70. Health & Hospitals	8.65	1.54	1.57	8.65	1.76	1.79	5.66	1.92	1.92	5.49	1.94	1.94
71. Hotels & Restaurants	5.16	0.97	0.98	4.93	1.00	1.03	4.55	1.76	1.78	4.33	1.81	1.82
72. Business Services	3.84	0.62	0.63	3.55	0.65	0.67	6.37	2.29	2.40	6.37	2.26	2.38
73. Other Services	3.53	1.64	1.69	3.50	1.78	1.83	5.29	2.04	2.13	5.22	1.97	2.06
74. Transport Margins (Dummy)	2.67	0.96	0.97	2.67	0.67	0.68	3.36	3.46	3.49	3.99	3.53	3.56
75. Other (Dummy)	0.98	0.36	0.39	1.03	0.38	0.40	3.35	1.24	1.26	3.28	1.37	1.40

(no. 39). Greater variations are observed, however, when one considers the "$L_{i.}$ indices. Examples of such greater variations can be discerned from indices with values like 7.91 for fishing (no. 3), declining to an index of 3.55 for pulpmaking (no. 22), and ending as low as 0.52 for finance, insurance and real estate (no. 67), in the year 1961. The same pattern is also noticeable in 1966 with a high index of 7.71 for fishing (no. 3), 3.80 for pulpmaking (no. 22), and declining as low as 0.54 for finance, insurance and real estate (no. 67). These variations in the indices suggest that indirect inter-relationships within the system as a result of changes in final demand would be fairly well dispersed, and sensitive to the composition of the bill of final demand.

Having discussed the results in terms of various indices, a comment should be made regarding their usefulness. In the author's opinion, two points can clearly be made. First, the indices, when looked at individually and compared with one another (for the years in question) provide a quantitative basis as to the extent and form of inter-relationships that would prevail given a bill of final demand. The summary measures so obtained can assist one in identifying "key sectors" in an economy. This theme is developed in chapter 6 of this study. Second, in almost all cases, when the various indices are compared over the two years we notice that their values tend to be smaller in the more recent year (1966) than in the earlier year (1961). This is an indication that technology is changing such that the requirements placed on the system are met with lesser amounts of intermediate inputs needed to produce them. This observation corroborates the results obtained in section 4.2.

CHAPTER 5

CHANGES IN DIRECT COEFFICIENTS: AN ANALYSIS OF THE TECHNOLOGY MATRIX B.

The analysis of structural change in the Canadian economy presented in chapter 4 is based on the combined effects (direct and indirect) of either the changing bill of final demand or the changes in coefficients themselves. Although it is a convenient way of summarizing the total impact, it may not be a true guide to the degree or direction of change in the <u>direct</u> requirements for the output of a <u>given</u> industry. In some instances, the direct and indirect impacts on the output of a given industry may offset each other and thus give an impression of little coefficient change over time. In other cases, the direct and indirect impacts may reinforce each other, and thus the combined impact of changes may be considerably larger than the changes in the direct coefficients. It is, therefore, desirable to examine changes in the direct coefficients themselves.

In this chapter we propose to analyze changes in the coefficients of the technology matrix B.[1] Changes in coefficients for the year 1961 relative to 1966 are examined. In section 5.1, we describe overall changes in coefficients for the whole economy. In section 5.2, for each industry, column measures analyzing the magnitude and direction of change are devised. Further, in this section, for each industry, we present a cell-by-cell analysis of coefficient changes. Finally in section 5.3, a cell-by-cell analysis of coefficient change for each commodity (that is, row-wise)

1) In this analysis it is being assumed that market share coefficients (d_{ij}'s) remain stable over time.

is presented.

5.1 OVERALL CHANGES IN DIRECT COEFFICIENTS.

The simplest index of change of any particular coefficient between two points in time could easily be formulated as the percentage difference between its original and its final value. Such a formulation, however, could yield some infinite values. To avoid this inconvenience, we relate the differences to the mean of the original and final values of the coefficients. The differences are expressed in relative (percentage) terms.

Let: b_{ij}^{61} = input coefficients for the year 1961; $i = 1,..,105$; $j = 1,.., 75$.

b_{ij}^{66} = input coefficients for the year 1966; $i = 1,...,105$; $j = 1,..., 75$.

be the two magnitudes of a particular input coefficient to be compared. Their difference is $(b_{ij}^{61} - b_{ij}^{66})$. Their mean is $(b_{ij}^{61} + b_{ij}^{66})/2$. An index of relative change can then be obtained as:

$$\bar{b}_{ij} = \frac{2(b_{ij}^{61} - b_{ij}^{66})}{b_{ij}^{61} + b_{ij}^{66}} \qquad (5.1)$$

If the description of the structural change of an economic system is presented in terms of an unweighted distribution of the indices of equation (5.1) -- each related to one particular input coefficient -- it would neglect the fact that some of the input ratios belong to large and others to comparatively small industries. This source of possible distortion of the individual indices should be weighted. In this analysis the individual indices have been weighted by the average value of the corresponding input items: $(u_{ij}^{61} + u_{ij}^{66})/2$.

A negative change in input requirements per unit of output can be loosely described as an increase in productivity (Leontief, 1953). The weighted distribution of all changes in coefficients for the years 1961-66 is shown in chart I. The distribution is approximately symmetric (mean of .008 and standard deviation of .274). Its mean can, therefore, serve as a statistical measure of the magnitude of overall change. We find that from 1961 to 1966 the input coefficients of all the cost elements (primary costs excluded) in all industries increased on the average by 0.8 per cent. Viewed in this manner it can be said that productivity (of non-primary inputs) declined slightly.[1)]

Relative changes in technical input coefficients, the distribution of which we have examined in chart I, are presented in Table 5.1 No interpretation is offered since the explanation of individual changes would require information not only on the flows of inputs but also on the stocks of machinery, equipment and other durables -- or at least on the storable factors involved in various productive processes in the different stages of their technical development. In the following two sections an attempt is made, however, to unravel changes at the industry and commodity level of detail.

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1) Carter (1970) interprets such a phenomenon as representing a change in the division of labour among establishments that does not in itself imply a deterioration of technology. See also chapter 4 (p.43) of our study on this point.

CHART - 1.

WEIGHTED DISTRIBUTION OF RELATIVE CHANGE IN TECHNOLOGY COEFFICIENTS: 1961 RELATIVE TO 1966.

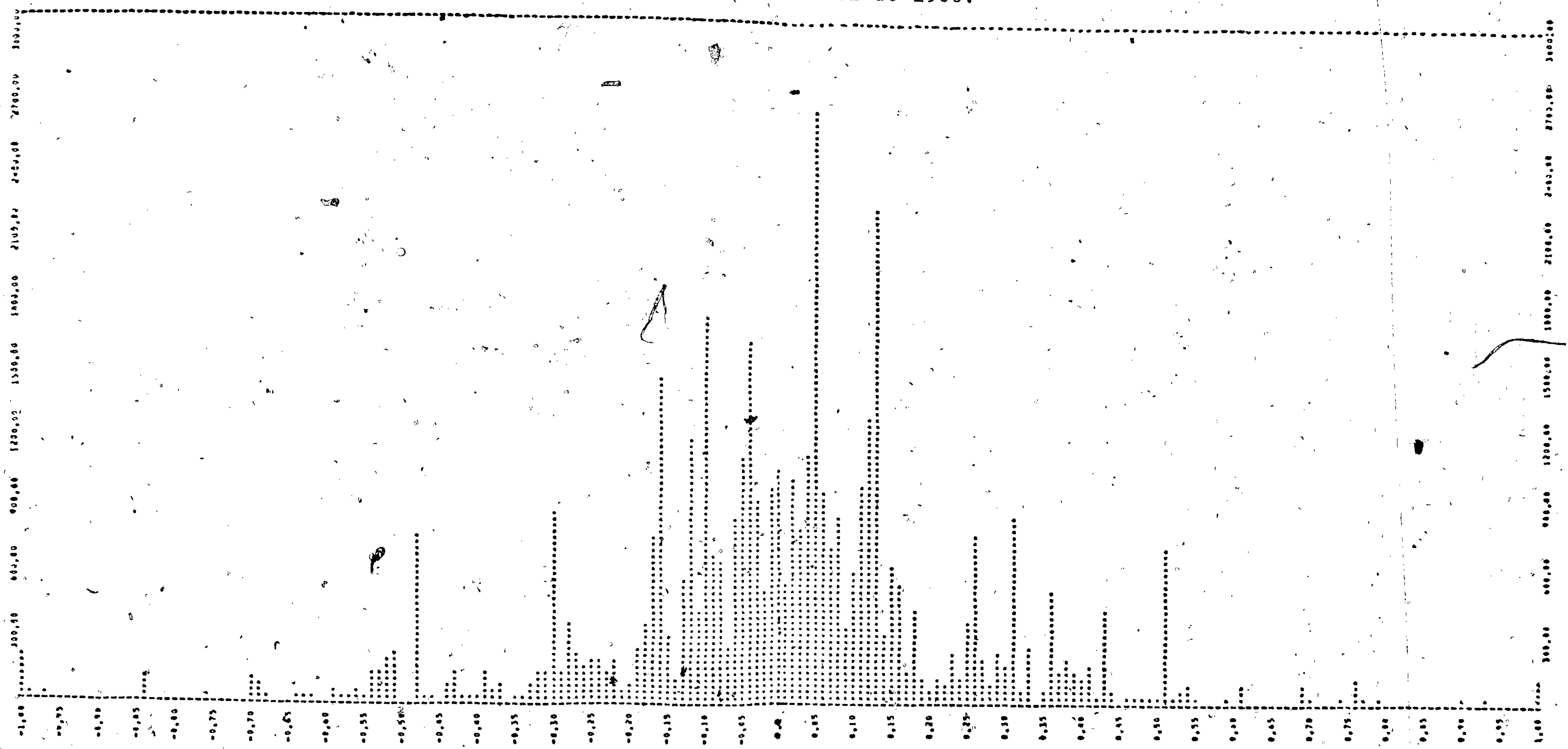

Table-5.1
RELATIVE CHANGE IN TECHNICAL INPUT
COEFFICIENTS, CANADA:
(1961-66)

Relative Change in Coefficients.	Number of Coefficients.	Weights $(u_{ij}^{61} + u_{ij}^{66})/2$ of changes in coeffs.**
-1.00 to -0.95	101	252.0
-0.95 to -0.90	14	-
-0.90 to -0.85	6	-
-0.85 to -0.80	11	112.0
-0.80 to -0.75	13	112.0
-0.75 to -0.70	18	112.0
-0.70 to -0.65	23	224.0
-0.65 to -0.60	28	84.0
-0.60 to -0.55	36	168.0
-0.55 to -0.50	31	700.0
-0.50 to -0.45	41	840.0
-0.45 to -0.40	47	476.0
-0.40 to -0.35	46	308.0
-0.35 to -0.30	60	1260.0
-0.30 to -0.25	78	1092.0
-0.25 to -0.20	83	672.0
-0.20 to -0.15	118	3164.0
-0.15 to -0.10	138	4284.0
-0.10 to -0.05	199	3528.0
-0.05 to 0	297	5124.0
0 to +0.05	290	6076.0
+0.05 to +0.10	202	3416.0
+0.10 to +0.15	157	5432.0
+0.15 to +0.20	114	1360.0
+0.20 to +0.25	88	896.0
+0.25 to +0.30	73	1428.0
+0.30 to +0.35	55	1260.0
+0.35 to +0.40	62	1092.0
+0.40 to +0.45	43	672.0
+0.45 to +0.50	48	140.0

Table 5.1(contd).

+0.50 to +0.55	34	1036.0
+0.55 to +0.60	22	-
+0.60 to +0.65	21	84.0
+0.65 to +0.70	16	84.0
+0.70 to +0.75	9	-
+0.75 to +0.80	19	196.0
+0.80 to +0.85	12	-
+0.85 to +0.90	15	-
+0.90 to +0.95	12	-
+0.95 to +1.00	147	112.0

** These are average values of the coefficients used as weights in computing relative change.

5.2 VARIABILITY OF COEFFICIENTS: MEASURING MAGNITUDE AND DIRECTION OF CHANGE, BY INDUSTRY.

The following index measures the magnitude of change in direct coefficients for 1961 to 1966 for industry j:

$$\gamma_{\cdot j}^{61,66} = \frac{\sum_i \left| b_{ij}^{61} - b_{ij}^{66} \right|}{\frac{1}{2} \sum_i \left(b_{ij}^{61} + b_{ij}^{66} \right)} \qquad (5.2)$$

This index is prepared by summing the absolute differences in all the coefficients in each column of the matrix and taking a ratio of this total to the average intermediate purchases of the industry. It allows the comparison of techniques of production of industries as given by their input coefficient matrix. The more similar the production structure in the years compared, the smaller will be the ratios.[1)] The comparison based on this index is shown in Table 5.2. Since we are computing absolute values of changes, these refer to the magnitude of changes only.

In order to obtain a better picture of the changes we have classified the changes in coefficients by the magnitude of their differ-

1) Chenery and Watanabe (1958) used this "absolute column measure" for an international comparison of production structures.

Table 5.2

COMPARISON OF PRODUCTION BETWEEN 1961 AND 1966 BY ABSOLUTE COLUMN MEASURE.*

Industry #	Value	Industry #	Value
1.	.23114	33	.18743
2.	.13585	34	.39651
3	.29197	35	.24855
4	.38758	36	.15756
5	.28191	37	.12590
6	.16683	38	.17427
7	.18487	39	.15354
8	.06761	40	.13428
9	.19641	41	.12179
10	.21170	42	.12765
11	.36959	43	.23083
12	.08195	44	.20757
13	.09221	45	.17196
14	.14542	46	.18919
15	.0905	47	.16038
16	.12641	48	.15733
17	.09515	49	.15722
18	.08324	50	.18545
19	.20862	51	.06103
20	.0173	52	.24174
21	.25054	53	.19364
22	.32256	54	.67091
23	.46591	55	.20275
24	.15067	56	.18258
25	.08664	57	.18201
26	.27033	58	.16163
27	.18005	59	.39065
28	.0643	60	.15148
29	.16268	61	.30508
30	.28739	62	.53161
31	.13562	63	.43791
32	.20222	64	.17129

Table 5.2 (contd)

Industry #	Value
65	.18648
66	.15743
67	.08121
68	.05931
69	.05789
70	.15906
71	.31301
72	.04918
73	.09883
74	.12715
75	.19426

* The Index is given by the following:

$$\gamma_{.j}^{61,66} = \frac{\sum_i \left| b_{ij}^{61} - b_{ij}^{66} \right|}{\frac{1}{2} \sum_i \left(b_{ij}^{61} + b_{ij}^{66} \right)} ,$$

$i = 1, \ldots, 105;$

$j = 1, \ldots, 75$

See Appendix A for the identification of these industries.

ences.[1] They are presented in Table 5.3. These differences are shown in terms of major industrial sectors such as manufacturing, mining, etc. A glance at this table reveals that very small changes (0-0.25) occurred in 60 out of 75 industries. The remaining 15 industries show changes of varying degrees (between 0.26 to 0.46 +). The most pronounced changes (0.36 +) occurred in 3 manufacturing industries -- grain mills, papermaking and railroad rolling stock; in metal mines; in pipeline transport; in radio and T.V.; and in two utilities - gas and water. These results provide a quantitative description of only the magnitude of differences in the average change in the coefficients, and would be more meaningfully interpreted if one also obtained the direction of these changes.

We measure direction of change in coefficients by considering the following weighted indices:

$$Q_{.j} = \frac{1}{\frac{1}{2}\sum_{i=1}^{105}(u_{ij}^{61} + u_{ij}^{66})} \cdot \sum_{i=1}^{105} \frac{2(b_{ij}^{61} - b_{ij}^{66})}{(b_{ij}^{61} + b_{ij}^{66})} (u_{ij}^{61} + u_{ij}^{66}) \quad ..(5.3)$$

where the u_{ij}'s refer to the use of commodity i by industry j (expressed in dollar values).

The indices are presented in Table 5.4. Both positive and negative

1) I interpret the coefficients between 0 and 0.25 to show a relatively small change. The interpretation of results could alter if an alternate range is chosen.

Table-5.3

CLASSIFICATION OF COLUMN DIFFERENCES
BY MAJOR INDUSTRIAL SECTORS.

Magnitude	Mfg.	Mining.	Const.	Transp.	Commun.	Util.	Others.	TOTAL
0 to 0.25	29	2	9	5	1	1	13	60
0.26 to 0.30	2	1	-	-	1	-	1	5
0.31 to 0.35	1	-	-	-	-	-	1	2
0.36 to 0.40	3	1	-	-	1	-	-	5
0.41 to 0.45	-	-	-	-	-	1	-	1
0.46 -	-	-	-	1	-	1	-	2
	35	4	9	6	3	3	15	75

Source: Table-5.2

Table-5.4

AVERAGE CHANGES IN INPUT COEFFICIENTS $(Q_{.j})$:[1)] DIRECTION OF CHANGE BY INDUSTRIES, CANADA, 1961-66.

Industry #	Values	Industry #	Values
1	0.11560	33	-0.02406
2	0.03207	34	-0.13847
3	-0.16150	35	-0.13117
4	-0.33594	36	0.00435
5	-0.13508	37	-0.02250
6	0.11512	38	0.01009
7	-0.04471	39	-.07117
8	--	40	-0.05179
9	-0.00255	41	-0.02449
10	-0.62212	42	0.00600
11	-0.01799	43	0.19120
12	-0.01872	44	0.10790
13	-0.02986	45	0.11130
14	0.00996	46	0.12852
15	-0.02699	47	0.04540
16	-0.00485	48	0.05133
17	-0.03836	49	0.04099
18	0.00477	50	0.06224
19	0.02538	51	0.04226
20	0.01634	52	0.05569
21	-0.10938	53	-0.09725
22	-0.01871	54	0.29269
23	-0.01600	55	0.12152
24	0.02882	56	0.11413
25	-0.01922	57	-0.04917
26	0.04258	58	0.00477
27	-0.01968	59	0.13717
28	0.01948	60	0.0420
29	-0.4223	61	-0.00425
30	-0.13165	62	-0.05512
31	0.05651	63	0.43264
32	-0.03941	64	-0.16281

Table-5.4 (contd).

Industry #	Values.
65	0.06357
66	-0.07577
67	-0.02049
68	0.05903
69	0.00496
70	0.08640
71	0.07739
72	-0.02446
73	0.04466
74	-0.00094
75	0.04790

Mean: 0.00429

....

1) This index is based on the following formulation:

$$Q_{.j} = \frac{1}{\frac{1}{2}\sum_{i=1}^{105}(u_{ij}^{61} + u_{ij}^{66})} \cdot \sum_{i=1}^{105} \frac{2(b_{ij}^{61} - b_{ij}^{66})}{(b_{ij}^{61} + b_{ij}^{66})} (u_{ij}^{61} + u_{ij}^{66})$$

(j = 1,....,75).

#) See Appendix A for the description of these industries.

values, indicating the direction of change in coefficients, are shown. On the average, the input ratios in most industries decrease slightly (0.4 per cent). We also find that in each major industrial sector most $Q_{.j}$ are increasing while others are becoming smaller - for 36 industries (out of a total of 75) the ratios are decreasing. This observation points directly to the question of product substitution in relation to structural change. The following interpretation (although very limited in its scope) is offered.

The substitution of a lower for a higher input ratio does not require any elaborate explanation whenever it can be construed as an independent technical change. A reduction in any one or more coefficients, with the rest of the input matrix remaining the same, will always result in a more efficient utilization of resources. It makes it possible to produce any given bill of goods with smaller total inputs of goods and services (Leontief, 1953).

An increase in various input ratios calls for a special explanation. It might be that changing external environments of production -- exhaustion of natural resources etc. -- occasionally cause increased input requirements. In most instances, however, one may surmise that an increase in the technical coefficients of certain kinds of inputs is associated with a reduction of the input ratios of some other commodities and services absorbed by the same industry. The adoption of a new method of production entails a simultaneous change in all its input ratios and the reduction in some of them could not, perhaps, be realized without corresponding increases in the other.

In chart 2 we present those industries that underwent pronounced positive and negative change. It is evident that the fish products industry (no. 10) registered the highest negative change, followed by metal mines (no. 4). The highest positive change was recorded for gas utilities (no. 63), which was followed by the pipeline transport industry (no. 54).

This analysis tends to point out the problem of the 'product mix' of industries. Since it involves individual input coefficients, the problem is better understood by analyzing the cell-by-cell variability of direct coefficients by industry.

The results of this cell-by-cell analysis are presented in Table 5.5.[1] Column (3) of this table represents the weighted average of the percentage change in direct coefficients for all of each industry's non-primary intermediate demand. Column (5) of the table shows the percentage of coefficients that move in the same direction (positive or negative) as the change registered in column (3).

There is a tendency for the majority of the industries consuming non-primary intermediate inputs to show coefficient changes in the same direction as the overall change. As can be seen from column (5), 50 out of the 75 industries examined showed coefficient changes of the same direction as the average for the majority of their individual inputs. Out of

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1) See notes to this table for the method of analysis on which these results are based.

Chart – 2

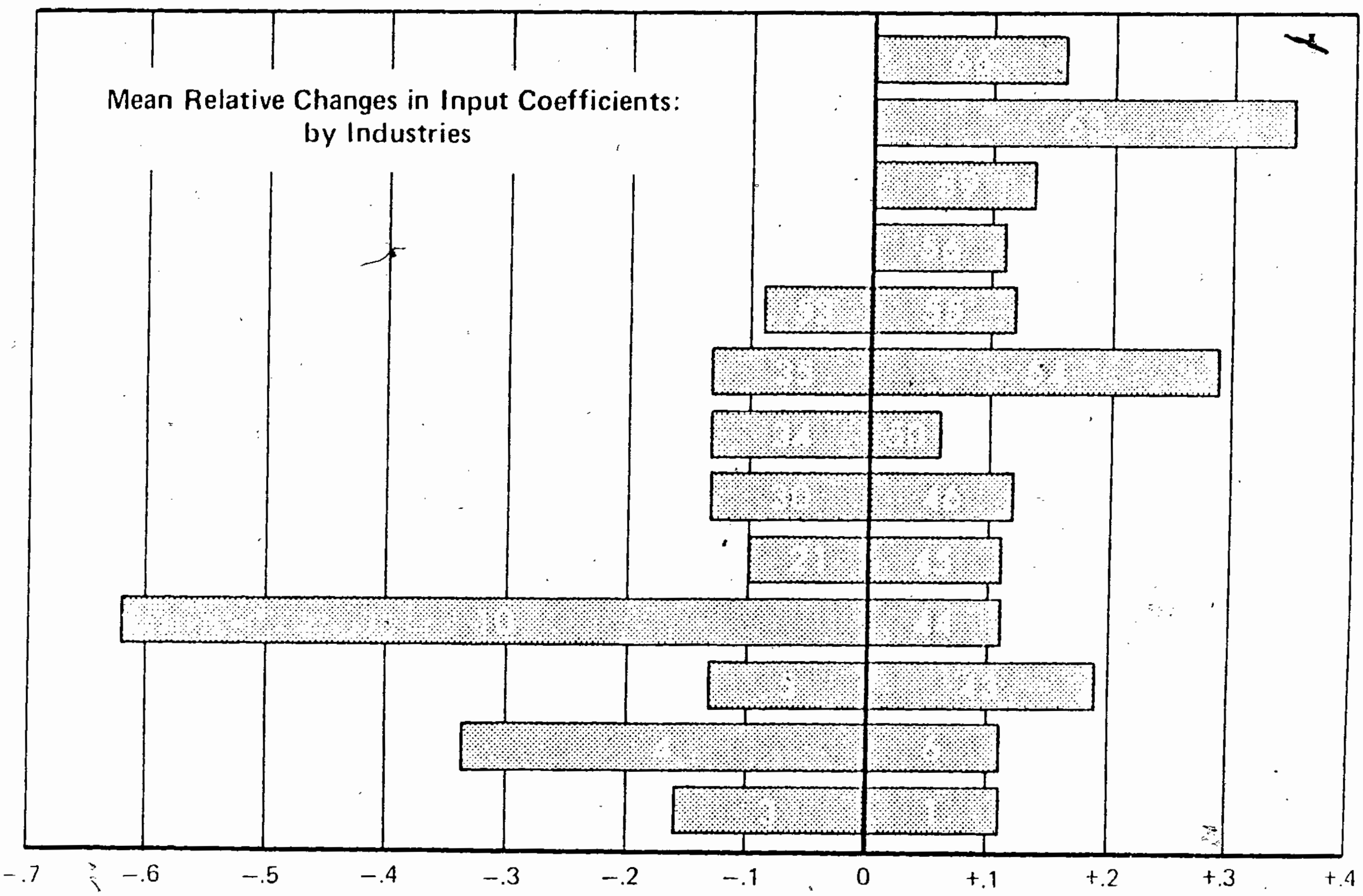
Mean Relative Changes in Input Coefficients:
by Industries
–.7
–.6
–.5
–.4
–.3
–.2
–.1
0
+.1
+.2
+.3
+.4

TABLE : 5.5

CELL-BY-CELL ANALYSIS OF VARIABILITY OF DIRECT COEFFICIENTS 1961-66, BY INDUSTRY

Industry Consuming a) *	Commodity a)	Percentage change in the Coefficients b)	No. of Coefficients analysed c)	Percent of Coefficients Conforming d)	Industry Consuming a)	Commodity a)	Percentage change in the Coefficients b)	No. of Coefficients analysed c)	Percent of Coefficients Conforming d)
1	2	3	4	5	1	2	3	4	5
1	ALL 17 105	+ 7.3 + 5.7 +36.5	42	76	11	ALL 1 86	- 1.8 +36.5 -83.2	50	42
2	ALL 105 3	+ 3.2 + 6.0 +13.6	31	48	12	ALL 22 2	- 0.5 + 1.3 - 0.9	51	51
3	ALL 56 78	-16.1 -68.2 +16.5	31	55	13	ALL 105 22	- 3.0 - 7.8 + 4.7	36	55
4	ALL 105 5	+33.6 -52.2 -27.2	39	77	14	ALL 2 24	+ 0.9 +13.2 - 5.4	22	27
5	ALL 105 90	-13.5 -32.6 - 7.9	17	73	15	ALL 64 29	- 2.7 - 1.3 - 5.9	43	72
6	ALL 95 105	+11.4 +11.0 +11.5	30	73	16	ALL 27 105	- 0.5 - 3.6 - 3.6	41	54
7	ALL 105 39	- 4.7 -18.1 + 8.7	36	47	17	ALL 28 29	- 3.8 - 3.1 - 4.3	51	61
8	ALL 2 14	~ - 3.9 + 6.4	43		18	ALL 29 28	+ 0.5 + 5.5 + 2.7	40	65
9	ALL 2 15	- 0.2 +13.7 - 4.2	44	70	19	ALL 3 32	+ 2.5 +11.7 +25.1	38	39
10	ALL 4 105	- 6.2 - 2.6 + 2.1	41	58	20	ALL 29 32	+ 1.6 + 3.7 - 4.1	42	59

* Refer to footnote on p. 74 for explanation.

1	2	3	4	5	1	2	3	4	5
21	ALL 105 90	-10.9 -21.8 + 2.1	36	39	35	ALL 42 49	-13.1 - 5.1 -62.3	40	72
22	ALL 35 3	- 1.9 -29.3 +43.1	19	31	36	ALL 47 26	+ 0.4 +10.3 +11.3	42	28
23	ALL 36 35	- 1.6 -47.5 +51.7	19	68	37	ALL 59 44	- 2.2 - 7.3 -30.5	52	44
24	ALL 38 39	+ 2.9 +13.4 +11.3	46	46	38	ALL 105 60	- 1.0 - 7.2 -31.4	57	47
25	ALL 38 37	- 1.9 - 4.9 +13.7	39	59	39	ALL 5 81	- 6.3 - 9.8 +38.9	35	51
26	ALL 42 105	[illegible] 1.7 + 6.9 - 6.3	46	35	40	ALL 64 63	- 5.2 - 5.4 + 8.7	45	55
27	ALL 12 44	- 1.9 +13.2 -16.1	49	63	41	ALL 64 105	- 2.4 - 2.2 - 2.5	63	54
28	ALL 42 47	+ 2.0 + 5.2 + 2.2	53	36	42	ALL 64 105	+ 2.6 + 0.4 +16.2	58	59
29	ALL 47 42	- 3.6 +12.5 -25.9	51	63	43	ALL 32 47	+19.1 - 8.3 +26.8	41	93
30	ALL 53 105	-13.5 -15.4 -24.8	46	41	44	ALL 47 33	+10.8 +18.6 - 4.6	48	71
31	ALL 47 53	+ 5.7 +13.6 - 1.3	44	59	45	ALL 47 59	+11.1 + 8.7 -15.3	54	76
32	ALL 53 42	- 4.0 - 5.3 -27.4	42	43	46	ALL 47 60	+13.4 + 7.7 - 5.7	41	80
33	ALL 54 105	- 2.4 + 8.8 -27.7	42	33	47	ALL 42 5	+ 4.5 + 6.8 -28.3	35	74
34	ALL 55 42	-13.8 - 7.2 - 2.8	37	54	48	ALL 47 59	+ 5.1 + 5.3 - 8.6	43	77

1	2	3	4	5
49	ALL 59 42	+ 4.1 - 9.3 + 7.6	41	73
50	ALL 47 42	+ 6.2 - 3.9 +41.0	43	67
51	ALL 105 95	+ 4.2 - 0.3 + 7.8	29	72
52	ALL 105 62	+ 5.6 -14.8 +26.8	25	52
53	ALL 78 105	- 2.0 +18.1 -13.8	42	50
54	ALL 105 95	+29.3 - 1.5 +106.0	15	20
55	ALL 78 90	+12.1 +17.6 +33.0	24	50
56	ALL 83 105	+11.4 +10.6 +33.4	36	86
57	ALL 105 84	- 4.7 - 5.7 -44.0	35	63
58	ALL 105 95	+ 0.5 -22.1 +27.7	25	76
59	ALL 100 88	+13.7 +15.2 -19.7	33	70
60	ALL 78 59	+ 4.2 + 0.3 +11.8	20	70
61	ALL 84 79	- 0.4 + 9.0 - 0.9	21	52
62	ALL 78 95	- 5.8 +16.5 +51.6	24	37
63	ALL 105 78	+43.3 +59.9 +42.1	15	100
64	ALL 104 105	-16.3 -20.1 -24.6	15	87
65	ALL 105 95	+ 6.3 - 4.9 + 5.2	61	49
66	ALL 105 95	- 8.0 -12.4 + 0.9	39	54
67	ALL 95 105	- 2.0 + 5.9 - 9.0	21	62
68	ALL 78 95	+ 5.9 + 4.2 +27.4	2	100
69	ALL 105 41	+ 0.5 - 0.7 - 0.9	33	27
70	ALL 105 95	+ 8.6 +10.7 + 8.8	32	47
71	ALL 14 105	+ 7.8 -27.0 - 1.5	47	47
72	ALL 105 102	- 2.4 - 3.7 - 9.7	26	35
73	ALL 105 95	+ 4.4 - 8.7 +11.6	46	78
74	ALL 80 84	- 0.09 +12.4 -11.3	4	75
75	ALL 41 103	+ 4.8 +31.4 + 5.8	59	49

these 50 industries, the direction of change for 24 happens to be positive, and the remaining 26 industries show a negative direction of change. These different directions are indicative of a changing 'product-mix' of the industries over the period under study. The explanation of the causes of change in 'product-mix' lies beyond the scope of the present analysis since it would involve studying the production processes of the industries in question.

Assuming that individual coefficient changes are a function of the changes at the industry level, one would have expected that the conformity of individual coefficient changes would be most marked for those industries that showed large average changes between 1961 and 1966. Similarly, non-conformity would be restricted to industries that showed relatively small average changes. The evidence does not support this. For instance, the pipeline industry (no. 54) shows an average change in all coefficients of 29.3 per cent but only 20 per cent of the coefficients follow this average pattern. The shipbuilding industry (no. 35), with

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* a) The numbering scheme of commodities and industries corresponds to the list in Appendix A.

b) For any given industry, the first entry in this column is a weighted average of the per cent change in the direct coefficients for all of its intermediate demand. The next two entries (in some cases one) show the percentage change in coefficients for the first and second largest commodity used by the given industry. The ranking of the size of the coefficient does not depend upon its values but has been determined by the level of the dollar flow observed in Use matrices.

c) This column shows the number of commodities (with non-zero coefficients) absorbed by a particular industry.

d) The figures in this column show the percentage of commodities (coefficients) that registered changes between 1961 and 1966 in the same direction as the change in the weighted average of the coefficients for all commodities for a given industry.

72 per cent of its coefficients conforming, registered a relatively small average change of -13.1 per cent for all its coefficients.

This seemingly unpatterned behaviour of changes between 1961 and 1966 in the various individual input coefficients is disconcerting. If one were to observe more regularity in the pattern of change, the task of updating and projecting coefficients based on the average pattern would be much easier.

5.3 CELL-BY-CELL ANALYSIS OF THE VARIABILITY OF DIRECT COEFFICIENT CHANGES, BY COMMODITY.

In a similar fashion, for the years 1961 and 1966, we examined technical coefficients in matrix B, cell-by-cell (row-wise, that is by commodity), to determine whether the input coefficients for the various direct users (industries) of a given commodity move in the same way as the overall average.

An examination of the data on individual input coefficients indicates a very marked degree of variability in the extent and direction of change over time. This is evident in Table 5.6. Commodities that exhibit positive changes in overall consumption by industries between 1961 and 1966 showed frequent decreases in coefficients into individual consuming industries. Likewise, commodities with overall negative changes in their direct consumption by industries showed numerous instances of increasing requirements for particular industrial consumers. Moreover, this opposite direction of movement was not necessarily confined to the small customers for a given commodity. Often, coefficients for the two largest intermediate customers for a commodity input changed in a direction opposite

TABLE : 5.6

CELL-BY-CELL ANALYSIS OF VARIABILITY OF DIRECT INPUT COEFFICIENTS, 1961-66:

ROW-WISE.

Commodity[a] #	Consuming[a] Industry	Percent Change[b] in the Coefficient	No. of Coeffic-[c] ients Analysed	Percent of Coeffi-[d] cients Conforming	Commodity[a] #	Consuming[a] Industry	Percent Change[b] in the Coefficient	No. of Coeffic-[c] ients Analysed	Percent of Coeffi-[d] Conforming
1	2	3	4	5	1	2	3	4	5
1	ALL 11 12	+32.4 +36.5 + 7.3	5	60	16	ALL 71 11	-51.8 -121.3 +18.3	12	50
2	ALL 8 9	+ 2.7 + 3.9 +13.7	31	61	17	ALL 1 11	+ 3.3 +55.7 -15.8	9	66
3	ALL 6 19	+25.1 +43.1 +11.7	35	60	18	ALL 12 71	+15.3 +15.6 +75.0	11	45
4	ALL 10 18	- 2.8 - 2.6 +36.8	8	75	19	ALL 11 1	+12.8 + 4.2 +20.7	15	73
5	ALL 39 47	-11.0 - 9.8 -28.3	12	75	20	ALL 71 75	+ 8.9 +33.9 -69.3	7	57
6	ALL 66 67	-52.0 +60.4 -73.3	54	89	21	ALL 71 75	+19.3 +73.6 -69.2	2	50
7	ALL 22 40	+48.2 +57.4 +14.4	12	100	22	ALL 12 71	+ 3.8 + 1.3 +54.1	28	57
8	ALL 26 62	+ 5.0 +24.6 - 1.3	52	69	23	ALL 75 13	+14.3 +13.6 +16.0	4	50
9	ALL 26 4	+68.7 +76.0 - 2.0	5	80	24	ALL 14	- 5.4 - 5.4	1	100
10	ALL 38 24	+34.6 +31.1 +67.8	8	87	25	ALL 75 30	+18.1 +16.5 +36.7	23	78
11	ALL 27 38	- 2.2 - 1.7 - 9.8	2	100	26	ALL 75 37	- 3.0 -23.1 - 4.7	42	36
12	ALL 27 42	+11.3 +13.2 +17.3	13	54	27	ALL 16 75	-10.4 - 3.7 -27.5	23	30
13	ALL 38 40	+17.5 + 1.6 + 3.7	48	71	28	ALL 17 18	- 2.9 - 3.1 - 2.7	23	30
14	ALL 8 71	-9.9 + 6.5 -26.9	18	50	29	ALL 18 17	+ 4.9 + 5.5 - 4.3	39	67
15	ALL 9 71	- 8.4 -42.3 +69.9	11	64	30	ALL 18 30	- 9.2 - 9.3 -75.6	60	48

1	2	3	4	5
31	ALL 18 66	- 8.1 -16.2 +29.9	13	53
32	ALL 19 44	- 2.1 +25.1 -15.1	35	57
33	ALL 44 22	- 8.7 - 4.6 -27.1	49	67
34	ALL 37 45	- 8.2 -24.5 + 5.6	15	60
35	ALL 23 22	+12.2 +51.7 -29.3	2	50
36	ALL 23 17	-47.0 -47.5 - 5.0	5	60
37	ALL 25 24	+14.8 +13.7 +36.5	2	100
38	ALL 24 25	+ 8.7 +13.4 - 4.9	44	54
39	ALL 12 75	+ 2.8 - 5.4 -32.1	54	61
40	ALL 71 75	-12.4 + 2.3 -26.7	13	77
41	ALL 75 25	+26.7 +31.4 + 2.3	30	60
42	ALL 28 26	+ 5.7 + 5.2 + 6.9	42	52
43	ALL 27 28	-16.0 -15.2 - 0.9	24	87
44	ALL 27 37	-15.2 -16.1 -30.5	24	58
45	ALL 27 26	+35.0 +37.5 + 8.8	18	61
46	ALL 27 28	- 2.6 -10.7 +14.8	31	48
47	ALL 45 28	+ 8.2 + 8.7 + 2.2	57	65
48	ALL 1 29	+30.7 +52.7 - 2.4	5	60
49	ALL 75 29	+15.1 +26.2 + 2.0	41	34
50	ALL 30	-200.0 -200.0	1	100
51	ALL 31 29	-16.7 - 0.5 -61.5	2	100
52	ALL 30 75	+35.6 +89.0 + 4.1	4	75
53	ALL 30 75	-16.4 -15.4 -29.4	23	87
54	ALL 33 52	+ 5.1 + 8.8 -14.4	4	50
55	ALL 53 34	-22.9 -34.2 - 7.2	8	87
56	ALL 35 56	-56.7 +12.8 -57.9	8	87
57	ALL 75 36	+89.5 +114.9 - 5.0	2	50
58	ALL 37 30	- 5.6 + 1.3 -51.6	17	41
59	ALL 37 45	- 9.1 - 7.3 -15.3	34	56
60	ALL 45 50	- 9.5 - 0.1 -10.2	12	75
61	ALL 45 44	+ 9.3 +13.9 +26.0	56	55
62	ALL 57 65	+14.2 +30.2 +16.4	71	77
63	ALL 40 46	+11.0 + 8.7 + 2.6	72	68
64	ALL 41 40	-5.5 - 2.2 - 5.4	57	49
65	ALL 1 41	+ 8.5 + 8.0 +11.3	13	54
66	ALL 41 70	-24.4 -46.3 - 8.9	11	54

1	2	3	4	5
67	ALL 75 41	+ 6.9 +7.2 + 9.2	62	61
68	ALL 75 70	-22.8 -51.1 +11.8	23	75
69	ALL 75 45	-27.4 -33.9 -15.4	36	53
70	ALL 75 42	+ 6.1 +10.9 - 4.7	53	49
71-77				
78	ALL 63 67	+ 6.0 + 4.2 + 3.0	61	75
79	ALL 75 74	-13.8 -17.2 -56.9	21	38
80	ALL 74 57	+ 9.9 +12.4 -27.9	35	57
81	ALL 39 54	+35.1 +38.9 +112.7	70	83
82	ALL 75	-200.0 -200.0	1	100
83	ALL 74 56	- 5.5 -16.1 +10.6	18	28
84	ALL 74 57	-11.4 -11.3 -44.0	65	49
85	ALL 65 1	+13.8 + 3.5 +26.6	14	78
86	ALL 11 26	+ 4.8 - 8.3 -51.4	73	70
87	ALL 75	+ 7.6 + 7.9	2	100
88	ALL 67 66	+ 2.1 -11.2 + 8.3	70	56
89	ALL 66 67	+10.3 +26.9 -31.9	69	59
90	ALL 66 21	+ 2.0 - 9.9 + 2.1	70	71
91	ALL 66 67	-25.0 -35.2 -46.1	65	54
92	ALL 40 67	-10.2 -83.5 -10.0	68	55
93	ALL 75 45	- 2.7 - 0.1 +23.7	73	64
94	ALL 75 45	+ 8.7 + 4.6 +40.0	73	55
95	ALL 67 66	+ 4.3 + 5.9 + 0.9	71	72
96-97				
93	ALL 67	+ 7.1 + 7.1	1	100
99	ALL 75 52	+15.0 +15.4 + 5.1	1	100
100	ALL 73 59	+11.8 +13.1 +15.2	5	40
101	ALL 73	+ 8.2 + 8.2	1	100
102	ALL 75 45	- 5.2 +33.8 -10.4	71	77
103	ALL 75	+ 5.8 + 5.8	1	100
104	ALL 75 67	- 1.6 - 4.1 -21.1	70	63
105	ALL 66 65	- 6.8 -12.4 - 4.9	70	73

a) The numbering scheme of Commodities and Industries corresponds to the list in Appendix-A. Commodity inputs refer to non-primary inputs.

b) For any given commodity, the first entry in this column is a weighted average of the percent change in the direct non-primary coefficients for all of its intermediate users. The next two entries (in some cases one) indicate the percent change in the direct non-primary coefficients for the 1st and 2nd largest user of the given commodity. The ranking of the user size is not determined by the size of the input coefficient, but by the level of the dollar flow observed in the USE matrices.

c) This column shows the number of industries that consume the given commodity.

d) The figures in this column shows the percentage of consuming industries that showed changes between 1961 and 1966 in the same direction as the change in the weighted average of the coefficients for all the customers of a given commodity.

to that of the overall average.

There is a tendency for the majority of the customers of a given commodity to show direct coefficients changes of the same direction as the overall change. As can be seen from column (5) of Table 5.6, 76 out of the 105 commodities examined showed coefficient changes of the same direction[1] as the average for the majority[2] of their individual consuming industries. It might be expected that the conformity of individual coefficient changes to the industry average would be most marked for those industries that showed large changes between 1961 and 1966 in their direct requirements, and that the cases of opposite direction of movement would be confined to those industries with small average changes over the period. This is not generally the case. For example, commodity 9 registered a relatively high percentage change (68.7%) in its use by all industries, with 80 per cent of the coefficients conforming to this average change. For commodity 19, on the other hand, with a relatively small percentage change of 12.7%, we notice that 73 per cent of the coefficients conform to the average change.

This unpatterned behaviour of changes between 1961 and 1966 for the various commodity inputs is similar to that observed in the cell-by-cell variability of direct coefficients by industry. If the pattern were found to be regular the task of updating and projecting these coefficients also would have been an easier one.

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1) 30 negative and 46 positive

2) Those with more than 50 per cent of the coefficients conforming.

CHAPTER 6

LINKAGES AND THE CONCEPT OF KEY SECTORS: AN ANALYSIS OF THE CANADIAN ECONOMY

Structural interdependence between the various sectors of an economy has provided the analytical basis for some of the propositions in the theory of growth. The interdependence of investment decisions has been analyzed mainly from two angles: the interdependence arising from the consumption side and that arising from production or technological relations. The former, inspired by an essentially Keynesian framework relating the expansion of industries to the generation of incomes and their disbursement led some to advocate the autonomous expansion of a complex of industries supporting each other through the simultaneous creation of effective demand. This approach emphasized the need for maintaining a balance between the relative rates of growth of the different sectors of an economy compatible with a given demand structure. The second aspect of interdependence, arising through technological interconnections between the various sectors of the economy, has led to exploration of the notion of 'key sectors' (Hirschman, 1958). The underlying idea is that some sectors, through their 'linkages' with other sectors, are in a favourable position to induce the expansion of other sectors (and sometimes even help the initiation of new industries). Thus, it is contended, a pattern of pressures and incentives can be worked out by investing initially in those sectors which have high technological linkages. What is advocated, therefore, is a sequential pattern of growth, the purpose being to select the most efficient sequence to accelerate the growth process.

The two related concepts of linkages and key sectors are examined in this chapter. A brief review of these concepts is presented in sections 6.1 and 6.2, respectively, and in section 6.3 empirical findings for Canada are discussed.

6.1 STRUCTURAL LINKAGES

Hirschman's (1958, chapter 6) significant contribution is that he provided a causal relationship to connect linkage effects with the process of economic development.[1] The structural linkages can be analyzed in two ways. An activity absorbs inputs from others, and, whenever it operates at a positive level, provides stimulus for the expansion (or initiation) of production in the input-providing industries. This has been termed the backward linkage effect. Second, an activity provides inputs to other industries, and, in so doing, either through the cheapening of its products or through greater availability, stimulates increases in the output levels of the absorbing industries. These have been called the forward linkage effects. The potential importance of a particular sector in generating growth depends upon the strength of these stimuli, and it is argued that the backward linkage effects, which are more powerful in their operation than the forward linkage effects, could be used as a basis for investment decisions.

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1) See Yotoponlos-Nugent (1973) on this point.

The input-output framework has been suggested as an empirical tool to quantify these linkages since it brings out in detail the production relations which prevail at a point in time.[1]

A measure of backward linkage for any industry is defined (Chenery and Watanabe, 1958) as the ratio of its intermediate consumption to its total output:

$$\sum_i u_{ij} / g_j \, , \qquad (6.1)$$

where u_{ij} are intermediate demands for commodity i by industry j, and g_j is industry output.

Correspondingly, the forward linkage for any industry j is estimated by computing the ratio of intermediate demand for the output of that industry (interindustry deliveries) to the total availability of the output of that industry:

$$\frac{\sum_j \sum_i d_{ji} \; u_{ji}}{\sum_j \sum_i d_{ji} \; u_{ij} + \sum_i d_{ji} \; e_i} \qquad (6.2)$$

or:

$$\frac{\sum_j \sum_i d_{ji} \; u_{ji}}{g_j + \sum_i d_{ji} \; m_i}$$

1) In a study by Chenery and Watanabe (1958) the degree of interdependence of various sectors has been computed on the basis of backward and forward linkages for the U.S., Japan, Norway and Italy in an input-output framework.

where:

$$\sum_j \sum_i d_{ji} u_{ij} + \sum_i d_{ji} e_i = g_j + \sum_i d_{ji} m_i \quad \text{since} \quad D(U + e) = D(q + m)$$
$$= Dq + Dm$$
$$= g + Dm$$

These are average measures, however, and do not give the distribution of inputs or deliveries among the various industries. Thus, these estimates of linkages do not distinguish between those industries which have highly skewed patterns of inputs or deliveries and those whose structural relations are more even. Also, since they are based upon the direct input requirements alone, the indirect and secondary repercussions of the input requirements are not included in the estimates.

A more refined way of computing these linkages is suggested by Rasmussen (1957) who makes use of the inverse of the input coefficients matrix for this purpose. These have already been defined in chapter 3 as equations (3.19) to (3.22). It should be recalled from the discussion of the results based on these equations in chapter 4.3 that the index $K_{.j} > 1$ indicates that industry j draws heavily on the rest of the system, and the converse is true for $K_{.j} < 1$. Similarly, $K_{i.} > 1$ would show that the industry in question will have to increase its output more than others for a unit increase in final demand from the whole system. Following this reasoning, the index of the power of dispersion, defined in equation (3.19), is analogous to the backward linkage effect; and the index of the sensitivity of dispersion, defined in equation (3.20), is analogous to the forward linkage effect. These average measures are supplemented by the measures of variability given in equations (3.21) and (3.22).

6.2 THE CONCEPT OF A KEY INDUSTRY.

Having defined backward and forward linkages, a key industry can then be identified as one for which:

(a) both $K_{.j}$ and $K_{i.}$ are greater than unity;

and (b) both $L_{.j}$ and $L_{i.}$ are relatively low.[1)]

This designation [2)] of a key industry can be defended by reference to the fact that if $K_{.j}$ is relatively large and $L_{.j}$ is relatively small, an increase in the final demand for the products of industry j would cause a relatively greater share of the increase in final demand to be returned to the system of industries in general. Further, it can be argued that its large effects on other industries are the most significant characteristics of a key industry.[3)]

The above formulation also follows Hirschman's characterization of a key industry. He defines a key industry as one which has a high backward as well as forward linkage. It should be pointed out, however, that Hirschman stipulates no restrictions on the values of $L_{.j}$ and $L_{i.}$ for

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1) Operationally, $L_{.j}$ and $L_{i.}$ are defined to be lower than the average of 75 industries examined.

2) A similar formulation, in a Leontief input-output framework, has been used by Hazari (1970) in determining key sectors in the Indian economy. Also see Laumas (1975).

3) For example, imagine a situation of general unemployment of resources. If the government wishes to increase final demand in such a way that economic activity is stimulated in several industries, final demand could be increased for the products of industries characterised by high $K_{.j}$ and low $L_{.j}$. An expansion in these industries would lead to a general increase in activity embracing most industries.

defining key sectors. He thus disregards the "spread effects" of the development of an industry. These effects are, nonetheless, very important for industrial diversification.

In conformity with the analysis of structural change (cf. chapter 4), key industries may also be identified by considering the $(C - I)$ and $(C - \hat{c})$ matrices. The corresponding indices are $('K_{.j}$ and $'K_{i.})$, $('L_{.j}$ and $'L_{i.})$, $(''K_{.j}$ and $''K_{i.})$, and $(''L_{.j}$ and $''L_{i.})$.

The indices described above are computed on the basis of the inverse matrices and hence the identification of key industries pursues technological considerations alone. In yet another fashion, key industries can be defined by considering final demand, given the technological structure. The focus in such an approach is the manipulation of the bill of final demand. Following Hazari (1970), we consider the following approach.

The gross output levels required to sustain a given vector of final demand are determined by $g = Cy$. $C_{.j}$ $(= \sum_{i=1}^{m} c_{ij})$ measures the total output needed to support a unit increase in final demand for the products of the j-th industry. $C_{i.}$ $(= \sum_{j=1}^{m} c_{ij})$ indicates the total output required to sustain a unit increase in final demand for the products of all industries.[1)]

1) See equations (3.11), (3.14) and (3.15), respectively.

All industries in which both $C_{.j}$ and $C_{i.}$ are high can be described as key industries. This procedure would, however, represent unweighted changes in gross output levels, implying that all industries are equally important. In order to bring out the relative importance of industries in the total economy, we have employed a weight consisting of the final demand of a particular industry as a proportion of total final demand. The following indices have been prepared to identify key industries in the Canadian economy:

$$\lambda_j = W_i C_{.j} \qquad (6.3)$$

$$\lambda_i = W_i C_{i.} \qquad (6.4)$$

where: $W_i = y_i / \sum_{i=1}^{m} y_i$ are the weights.[1)]

Industries for which both λ_j and λ_i are high[2)] can be defined as key industries.

6.3 DISCUSSION OF FINDINGS

Key industries in the Canadian economy for 1961 and 1966 have been identified on the basis of technological considerations as well as from the viewpoint of final demand. Methods I and II correspond to these

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1) These weights are the same for both indices.

2) Operationally, λ_j and λ_i are defined to be higher than the average computed for 75 industries examined.

identification procedures. These methods, besides considering matrix C itself, also utilize two more matrices, (C - I) and (C - $\hat{c}$), for identifying key industries. Matrix C, it will be recalled (cf. chapter 4), deals with both direct and indirect effects on the output levels consistent with a given bill of final demand. Analysis of matrix (C - I) concentrates on indirect effects. Matrix (C - $\hat{c}$), however, considers indirect effects on other industries only -- that is, exclusive of the industry under consideration, so that the feedback effects on the industry itself are disregarded.

<u>METHOD I</u>: Using this method, three indices corresponding to each of the matrices mentioned have been prepared for the years 1961 and 1966. Key industries identified on the basis of these indices are shown in Tables 6.1, 6.2 and 6.3 for 1961 and in Tables 6.4, 6.5 and 6.6 for the year 1966.

An examination of these tables reveals that in both years and for all indices, the number of industries with high backward linkages is higher than the number of industries having high forward linkages.[1)] This is not a surprising result, since in an industrialized economy like Canada one would expect a large number of industries to rely on the rest of the production system for their input provision.

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1) A comparison between 1961 and 1966 shows that the number of industries with high backward linkages is 38, 24, and 23 in 1966 for three indices used, respectively. In 1961, there were 35, 21, and 18 industries with high backward linkages, respectively.

TABLE 6.1 LINKAGES AND KEY INDUSTRIES IN THE CANADIAN ECONOMY: 1961

Industries.	High Forward Linkage and Low Coeff. of Variation.*		Industries.	High Backward Linkage and Low Coeff. of Variation. **		Industries.	Key Industries. Method I, Index I.			
	$K_{i.}$	$L_{i.}$		$K_{.j}$	$L_{.j}$		$K_{i.}$	$K_{.j}$	$L_{i.}$	$L_{.j}$
1.	2.10	3.00	8.	1.34	4.09	23.	1.22	1.44	3.69	3.71
2.	1.31	3.90	9.	1.27	4.02	25.	1.41	1.01	3.18	4.54
4.	1.22	3.70	10.	1.14	4.08	26.	2.05	1.04	2.51	4.63
6.	1.46	3.25	11.	1.32	3.72	28.	2.20	1.10	2.19	4.41
17.	1.53	4.13	12.	1.13	4.15	29.	1.18	1.05	3.78	4.38
19.	1.05	4.50	14.	1.29	4.32	37.	1.36	1.10	3.65	4.47
21.	1.54	3.49	15.	1.01	4.24	38.	1.10	1.02	4.18	4.55
23.	1.22	3.69	16.	1.19	4.33	39.	1.44	1.37	2.86	4.25
24.	1.02	4.30	18.	1.15	4.32	41.	1.32	1.17	3.45	4.55
25.	1.41	3.18	19.	1.12	4.38					
26.	2.05	2.51	20.	1.08	3.93					
27.	1.74	3.69	22.	1.35	3.55					
28.	2.20	2.19	23.	1.44	3.71					
29.	1.18	3.78	24.	1.34	3.56					
32.	1.11	4.64	25.	1.01	4.54					
37.	1.36	3.65	26.	1.04	4.63					
38.	1.10	4.18	28.	1.10	4.41					
39.	1.44	2.86	29.	1.05	4.38					
40.	1.22	3.78	30.	1.24	3.62					
41.	1.32	3.45	31.	1.18	3.54					
43.	1.41	2.91	32.	1.15	4.29					
53.	1.51	3.11	34.	1.14	4.22					

[redacted]

(Table 6.1 continued).

	$K_{i.}$	$L_{i.}$		$K_{.j}$	$L_{.j}$	$K_{i.}$	$K_{.j}$	$L_{i.}$	$L_{.j}$
57.	1.39	3.22	37.	1.10	4.47				
62.	1.06	3.89	38.	1.02	4.55				
65.	1.89	2.17	39.	1.37	4.25				
66.	1.24	3.30	41.	1.17	4.00				
67.	2.36	1.88	42.	1.06	4.09				
72.	1.08	3.84	44.	1.09	3.81				
73.	1.27	3.30	45.	1.13	3.69				
			46.	1.07	3.87				
			47.	1.11	3.83				
			48.	1.13	3.69				
			49.	1.16	3.63				
			50.	1.20	3.52				
			59.	1.17	3.85				

*Average $L_{i.}$ = 5.65

** Average $L_{.j}$ = 4.70

TABLE 6.2 LINKAGES AND KEY INDUSTRIES
IN THE CANADIAN ECONOMY: 1961

Industries.	High Forward Linkage and Low Coeff. of Variation.*		Industries.	High Backward Linkage and Low Coeff. of Variation.**		Industries.	Key Industries. Method I, Index II.			
	$'K_{i.}$	$'L_{i.}$		$'K_{.j}$	$'L_{.j}$		$'K_{i.}$	$'K_{.j}$	$'L_{i.}$	$'L_{.j}$
19.	1.10	1.68	12.	1.25	1.69	26.	3.01	1.08	1.48	1.91
24.	1.04	1.02	15.	1.02	1.90	29.	1.35	1.09	0.79	1.91
25.	1.78	0.96	16.	1.36	1.87	37.	1.69	1.20	1.60	1.93
26.	3.01	1.48	20.	1.15	1.56	38.	1.21	1.03	1.56	1.59
28.	3.28	1.01	26.	1.08	1.91	41.	1.62	1.32	0.79	1.69
29.	1.35	0.79	29.	1.09	1.91					
37.	1.69	1.60	31.	1.34	1.61					
38.	1.21	1.56	32.	1.29	2.03					
39.	1.85	0.70	33.	1.08	2.07					
40.	1.42	1.38	34.	1.27	1.84					
41.	1.62	0.79	36.	1.19	1.46					
43.	1.78	0.90	37.	1.20	1.93					
62.	1.11	0.69	38.	1.03	1.59					
65.	2.69	0.50	41.	1.32	1.69					
66.	1.46	0.67	42.	1.12	1.53					
67.	3.59	0.51	44.	1.17	1.42					
72.	1.17	0.65	45.	1.24	1.62					
			46.	1.13	1.56					
			48.	1.25	1.73					
			49.	1.31	1.91					
			50.	1.37	1.77					

*Average $'L_{i.}$ = 1.71 ** Average $'L_{.j}$ = 2.21

TABLE 6.3 LINKAGES AND KEY INDUSTRIES
IN THE CANADIAN ECONOMY: 1961

Industries.	High Forward Linkage and Low Coeff. of Variation. *		Industries.	High Backward Linkage and Low Coeff. of Variation. **		Industries.	Key Industries. Method I, Index III.			
	$''K_{i.}$	$''L_{i.}$		$''K_{.j}$	$''L_{.j}$		$''K_{i.}$	$''K_{.j}$	$''L_{i.}$	$''L_{.j}$
24.	1.04	0.96	12.	1.21	1.69	29.	1.35	1.07	0.66	1.97
25.	1.81	0.96	15.	1.07	1.96	41.	1.61	1.30	0.66	1.71
27.	2.04	1.26	16.	1.22	1.54					
28.	3.38	1.04	20.	1.21	1.60					
29.	1.35	0.66	29.	1.07	1.97					
39.	1.96	0.72	31.	1.44	1.61					
40.	1.40	1.38	32.	1.20	2.01					
41.	1.61	0.66	34.	1.21	1.84					
43.	1.91	0.91	36.	1.27	1.46					
60.	1.03	0.98	37.	1.09	1.79					
62.	1.18	0.71	41.	1.30	1.71					
65.	2.86	0.52	42.	1.15	1.58					
66.	1.56	0.68	44.	1.25	1.63					
67.	3.74	0.51	45.	1.33	1.62					
72.	1.22	0.67	46.	1.21	1.56					
			48.	1.35	1.73					
			49.	1.41	1.91					
			50.	1.47	1.77					

* Average $''L_{i.}$ = 1.51   **Average $''L_{.j}$ = 2.18

TABLE 6.4 LINKAGES AND KEY INDUSTRIES
IN THE CANADIAN ECONOMY: 1966

Industries	High Forward Linkage and Low Coeff. of Variation.*		Industries.	High Backward Linkage and Low Coeff. of Variation. **		Industries.	Key Industries Method I, Index I.			
	$K_{i.}$	$L_{i.}$		$K_{.j}$	$L_{.j}$		$K_{i.}$	$K_{.j}$	$L_{i.}$	$L_{.j}$
1.	1.90	3.14	9.	1.26	4.07	19.	1.07	1.10	4.35	4.38
2.	1.20	4.05	10.	1.90	3.78	22.	1.16	1.32	4.15	3.68
4.	1.10	4.08	11.	1.36	3.57	23.	1.12	1.59	3.97	3.51
6.	1.53	3.25	12.	1.14	4.14	24.	1.02	1.34	4.29	3.49
7.	1.50	4.23	14.	1.27	4.43	25.	1.22	1.04	3.67	4.39
19.	1.07	4.35	15.	1.04	4.17	26.	2.04	1.03	2.52	4.61
21.	1.50	3.65	16.	1.19	4.39	28.	2.18	1.08	2.22	4.46
22.	1.16	4.15	18.	1.17	4.35	29.	1.17	1.08	3.84	4.30
23.	1.12	3.97	19.	1.10	4.38	32.	1.17	1.18	4.45	4.22
24.	1.02	4.29	20.	1.07	3.98	37.	1.45	1.13	3.49	4.44
25.	1.22	3.67	22.	1.32	3.68	38.	1.14	1.01	4.18	4.72
26.	2.04	2.52	23.	1.59	3.51	39.	1.30	1.17	3.18	4.26
27.	1.79	3.65	24.	1.34	3.49	40.	1.26	1.05	3.70	4.62
28.	2.18	2.22	25.	1.04	4.39	41.	1.28	1.19	3.58	3.95
29.	1.17	3.84	26.	1.03	4.61	42.	1.03	1.06	4.21	4.15
32.	1.14	4.18	28.	1.09	4.46					
37.	1.45	3.49	29.	1.08	4.30					
38.	1.03	4.21	30.	1.39	3.68					
39.	1.30	3.18	31.	1.15	3.66					
40.	1.26	3.70	32.	1.18	4.22					
41.	1.28	3.58	33.	1.06	4.66					
42.	1.03	4.21	34.	1.21	3.88					
43.	1.31	3.15	36.	1.10	3.79					

[redacted]

Table 6.4 (continued).

	$K_{i.}$	$L_{i.}$		$K_{.j}$	$L_{.j}$
53.	1.41	3.27	37.	1.13	4.44
57.	1.52	3.07	38.	1.01	4.72
65.	2.00	2.05	39.	1.17	4.26
66.	1.24	3.32	40.	1.05	4.62
67.	2.25	1.97	41.	1.19	3.95
72.	1.10	3.84	42.	1.06	4.15
73.	1.25	3.53	44.	1.02	4.07
			45.	1.06	3.94
			47.	1.08	3.96
			48.	1.10	3.82
			49.	1.14	3.74
			50.	1.15	3.67
			59.	1.01	4.41
			64.	1.02	4.14

* Average $L_{i.} = 5.53$

** Average $L_{.j} = 4.74$

TABLE 6.5 LINKAGES AND KEY INDUSTRIES IN THE CANADIAN ECONOMY: 1966.

Industries.	High Forward Linkage and Low Coeff. of Variation.*		Industries.	High Backward Linkage and Low Coeff. of Variation.**		Industries.	Key Industries. Method I, Index II.			
	$'K_{i.}$	$'L_{i.}$		$'K_{.j}$	$'L_{.j}$		$'K_{i.}$	$'K_{.j}$	$'L_{i.}$	$'L_{.j}$
19.	1.15	1.63	12.	1.27	1.68	24.	1.05	1.66	0.96	2.10
24.	1.05	0.96	15.	1.07	1.88	25.	1.41	1.08	0.93	2.10
25.	1.41	0.93	16.	1.36	1.91	26.	2.98	1.07	1.49	1.77
26.	2.98	1.49	20.	1.14	1.58	29.	1.33	1.15	0.85	1.93
28.	3.25	0.99	24.	1.66	2.10	37.	1.86	1.26	1.58	2.03
29.	1.33	0.85	25.	1.08	2.10	38.	1.27	1.02	1.62	1.76
37.	1.86	1.58	26.	1.07	1.77	40.	1.49	1.01	1.33	1.57
38.	1.27	1.62	29.	1.15	1.93	41.	1.52	1.36	0.82	1.69
39.	1.57	0.71	31.	1.28	1.65	42.	1.06	1.12	0.77	1.51
40.	1.49	1.33	32.	1.34	2.10					
41.	1.52	0.82	33.	1.12	1.94					
42.	1.06	0.77	34.	1.40	1.76					
43.	1.59	0.96	36.	1.19	1.48					
57.	1.99	1.77	37.	1.26	2.03					
62.	1.06	0.71	38.	1.02	1.76					
65.	2.92	0.48	40.	1.01	1.57					
66.	1.47	0.68	41.	1.36	1.69					
67.	3.39	0.53	42.	1.12	1.51					
72.	1.19	0.62	44.	1.05	1.71					
73.	1.48	1.63	45.	1.11	1.68					
			48.	1.19	1.83					
			49.	1.27	2.05					
			50.	1.37	1.76					
			64.	1.03	2.07					

*Average $'L_{i.}$ = 1.80 **Average $'L_{.j}$ = 2.20

TABLE 6.6 LINKAGES AND KEY INDUSTRIES
IN THE CANADIAN ECONOMY: 1966.

Industries.	High Forward Linkage and Low Coeff. of Variation.*		Industries.	High Backward Linkage and Low Coeff. of Variation.**		Industries.	Key Industries. Method I, Index III.			
	$''K_{i.}$	$''L_{i.}$		$''K_{.j}$	$''L_{.j}$		$''K_{i.}$	$''K_{.j}$	$''L_{i.}$	$''L_{.j}$
24.	1.05	0.92	11.	1.69	2.17	24.	1.05	1.71	0.92	2.17
25.	1.43	0.90	12.	1.23	1.67	29.	1.33	1.13	0.72	1.99
27.	2.13	1.25	13.	1.04	1.72	41.	1.52	1.17	0.69	1.72
28.	3.35	1.01	15.	1.12	1.93	42.	1.08	1.06	0.71	1.56
29.	1.33	0.72	16.	1.20	1.53					
39.	1.67	0.73	20.	1.20	1.62					
40.	1.48	1.32	24.	1.71	2.17					
41.	1.52	0.69	29.	1.13	1.99					
42.	1.08	0.71	31.	1.38	1.64					
43.	1.71	0.97	32.	1.26	2.13					
60.	1.02	1.12	33.	1.01	1.73					
62.	1.12	0.73	34.	1.38	1.80					
65.	3.11	0.49	36.	1.28	1.49					
66.	1.56	0.70	37.	1.15	1.94					
67.	3.54	0.55	41.	1.17	1.72					
72.	1.24	0.63	42.	1.06	1.56					
			44.	1.12	1.71					
			45.	1.19	1.68					
			46.	1.06	1.66					
			48.	1.28	1.83					
			49.	1.36	2.05					
			50.	1.37	1.76					
			64.	1.11	2.07					

* Average $''L_{i.} = 1.46$ ** Average $''L_{.j} = 2.19$

Based on index I we find that there were nine key industries in 1961, whereas this number rose to fifteen in 1966 (Tables 6.1 and 6.4). A scrutiny of these tables shows further that the nine key industries identified in 1961 still remained key industries in 1966. In addition, six more industries emerged as key industries in 1966. They are: wood (no. 19), pulp-making (no. 22), paper converters (no. 24), parts and accessories (no. 32), industrial chemicals (no. 40) and miscellaneous manufactures (no. 42).

An examination of Tables 6.2 and 6.5 (index II) reveals that there were five key industries in 1961; whereas this number rose to nine in 1966. Those identified as key industries in 1961 remained so in 1966. However, four more industries that emerged as key industries in 1966 are: paper converters (no. 24), printing and publishing (no. 25), industrial chemicals (no. 40), and miscellaneous manufactures (no. 42).

Looking at Tables 6.3 and 6.6 (index III), we find that the number of key industries increased to four in 1966 from two in 1961. Those identified as key industries in 1961 remained key industries in 1966. Those which emerged as key industries in 1966 are: paper converters (no. 24) and miscellaneous manufactures (no. 42).

The analysis of key industries thus far reveals that the number of key industries identified is consistently larger in 1966 than in 1961 for the indices employed. Furthermore, for both years, and for all indices, the number of key industries identified is sensitive to the variant of matrix C examined.[1] Another interesting feature is that those key industries identified on the basis of index III are also the key industries picked up by indexes I and II. One could say, relatively speaking, that they occupy a rather "unique" position in the production system in so far as their growth potential is concerned.[2]

<u>METHOD II</u>: According to this method, key industries are defined with respect to the bill of final demand. These are identified by indices λ_j and λ_i. Results are presented in Tables 6.7 for 1961 and in Table 6.8 for the year 1966. Each of these tables refers to the examination of matrices C, (C - I), and (C - $\hat{c}$), respectively, corresponding to indices I, II and III.

Based on index I we find that there were 18 key industries in 1961, whereas this number declined to 17 in 1966 (Tables 6.7 and 6.8). An examination of these tables reveals further that the 16 key industries identified in 1961 still remain key industries in 1966. However, petroleum and coal products (no. 39) and non-residential construction (no. 45), which were key industries in 1961, do not appear so in 1966. Machinery (no. 29)

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1) It is observed that in 1961 there were nine key industries identified by matrix C; this number decreases to five on the basis of matrix (C - I); and utilizing matrix (C - $\hat{c}$) this number declines further to two. Correspondingly, this sequence in 1966 was 15, 9 and 4 industries.

2) Key industries with such distinction in 1961 were: machinery (no. 29), and chemical products (no. 41); whereas, in 1966, we observe paper converters (no. 24), and miscellaneous manufactures (no. 42) in addition.

TABLE 6.7 KEY INDUSTRIES IN THE CANADIAN ECONOMY, 1961: METHOD II

Industries.	Index I λ_j	Index I λ_i	Industries.	Index II $'\lambda_j$	Index II $'\lambda_i$	Industries.	Index III $''\lambda_j$	Index III $''\lambda_i$
1.	0.040	0.091	1.	0.020	0.070	1.	0.018	0.069
8.	0.077	0.043	12.	0.051	0.031	12.	0.046	0.026
12.	0.087	0.067	23.	0.048	0.037	23.	0.047	0.036
18.	0.066	0.034	27.	0.035	0.055	27.	0.023	0.043
23.	0.071	0.060	37.	0.022	0.030	37.	0.018	0.027
27.	0.055	0.075	39.	0.020	0.030	39.	0.020	0.029
30.	0.071	0.031	65.	0.031	0.125	65.	0.030	0.124
37.	0.038	0.047	66.	0.067	0.174	66.	0.065	0.173
39.	0.071	0.044	67.	0.036	0.291	67.	0.028	0.283
44.	0.104	0.045	71.	0.044	0.032	71.	0.044	0.032
45.	0.129	0.054	73.	0.017	0.038	73.	0.016	0.037
65.	0.073	0.166	74.	0.042	0.054	74.	0.041	0.055
66.	0.174	0.282						
67.	0.109	0.365						
68.	0.095	0.075						
71.	0.086	0.075						
73.	0.039	0.060						
74.	0.066	0.080						

Average: λ_j = 0.027 $\quad '\lambda$ = 0.014 $\quad ''\lambda$ = 0.013

Average: λ_i = 0.029 $\quad '\lambda$ = 0.016 $\quad ''\lambda$ = 0.015

TABLE 6.8 KEY INDUSTRIES IN THE CANADIAN ECONOMY, 1966: METHOD II

Indus. tries.	Index I λ_j	Index I λ_i	Indus-tries.	Index II $'\lambda_j$	Index II $'\lambda_i$	Indus-tries.	Index III $''\lambda_j$	Index III $''\lambda_i$
1.	0.067	0.147	12.	0.045	0.027	12.	0.041	0.023
8.	0.067	0.041	23.	0.046	0.026	23.	0.046	0.026
12.	0.077	0.060	27.	0.032	0.048	27.	0.022	0.038
18.	0.059	0.032	29.	0.017	0.021	29.	0.016	0.019
23.	0.066	0.046	37.	0.025	0.037	37.	0.021	0.034
27.	0.050	0.065	39.	0.016	0.019	39.	0.016	0.019
29.	0.032	0.035	65.	0.027	0.128	65.	0.026	0.127
30.	0.107	0.053	66.	0.062	0.153	66.	0.061	0.151
37.	0.044	0.056	67.	0.035	0.262	67.	0.027	0.255
44.	0.091	0.042	71.	0.032	0.023	71.	0.032	0.023
65.	0.067	0.168	73.	0.016	0.037	73.	0.015	0.036
66.	0.158	0.248	74.	0.025	0.034	74.	0.025	0.033
67.	0.105	0.332	75.	0.044	0.194	75.	0.041	0.191
68.	0.081	0.066						
71.	0.067	0.059						
73.	0.039	0.060						
74.	0.039	0.048						

Average: λ_j = 0.027 $'\lambda_j$ = 0.014 $''\lambda_j$ = 0.013

Average λ_i = 0.031 $'\lambda_i$ = 0.018 $''\lambda_i$ = 0.017

emerged as a key industry in 1966.

According to index II there is a marginal increase in the total number of key industries. It rose from 12 in 1961 to 13 in 1966. Eleven key industries were identical in both years. Agriculture (no. 1), a key industry in 1961, lost its key position in 1966. Two industries that emerged as key industries in 1966 are: machinery (no. 29) and dummy: other (no. 75).

Similarly, the number of key industries identified as per index III rose from 12 in 1961 to 13 in 1966. Eleven industries identified in 1961 still remained key industries in 1966. Agriculture (no. 1), a key industry in 1961, does not appear thus in 1966. Machinery (no. 29) and dummy: other (no. 75) emerged as key industries in 1966.

This analysis of key industries based on final demand considerations shows that, for both years, and for all the three matrices examined, there are ten industries that consistently show up as key industries. These are: other food and soft drinks (no. 12), paper-making and other activities (no. 23), primary non-ferrous (no. 27), electrical products (no. 37), wholesale trade (no. 65), retail trade (no. 66), finance, insurance and real estate (no. 67), hotels and restaurants (no. 71), other services (no. 73), and dummy: transport margins (no. 74). Furthermore, a close scrutiny of indices II and III warrants an interesting observation. We find that, for both years, the total number of key industries identified remains unchanged; in 1961 at 12 and at 13 in 1966. Their composition also remains identical.[1)]

1) Although values obtained for respective indices used are different.

CHAPTER 7

QUANTIFICATION OF THE CONCEPT OF BALANCE/IMBALANCE: AN ANALYSIS OF THE CANADIAN ECONOMY, 1961-70

Despite active theoretical discussions in recent years, controversy still exists regarding balanced/unbalanced growth as competing policy objectives.[1] Empirical investigations into the nature and process of sectoral growth rate dispersion are scarce.[2] This is partly a result of the paucity of relevant statistical data and partly a result of the lack of precise operational concepts required to examine the problem. In this chapter we first review briefly three studies relevant to present objectives that have been instrumental in defining operationally the concept of balance/imbalance. Secondly, we use some of the formulations employed in these studies to analyze sectoral balance/imbalance in the Canadian economy during the 1960's. Sections 7.1 and 7.2 deal with these aspects, respectively. In section 7.3 empirical findings are presented.

7.1 THE CONCEPT OF BALANCE/IMBALANCE: A BRIEF REVIEW OF SOME EMPIRICAL INVESTIGATIONS

The balanced growth theorists specify a positive association between balance on the one hand and the overall growth rate in national

1) Swamy (1967)

2) The following studies have been cited by Swamy (1967): Gerschenken (1952), Rostow (1956) and Ohlin (1959) have examined the balanced-growth thesis for historical relevance; another study by Williamson (1965) has concentrated on the empirical investigation into the nature of the spatial inequality within national borders and over the development spectrum.

income per capita. This relationship is reversed for the proponents of the unbalanced growth thesis. The discussion on causality between balance and development is, however, less clear. In general, the flow of causation seems to run from balance/imbalance to development.[1)] Nurkse (1953; 1961) advocated balanced growth on the grounds that it increases the reinvestible surplus, provides inducements to invest, creates external economies in complementary industries and, as a result, leads to more rapid economic development. On the opposite side of the argument, Hirschman (1958) perceives the causal link between imbalance and development in terms of external economies of the vertical type.[2)]

In two articles, one by Swamy (1967) and another by Yotopoulos-Lau (1970), the criterion of balance/imbalance has been spelled out in terms of the dispersion of sectoral growth rates. The operational definition is based on Solow and Samuelson's (1953) study which stipulates:

> "... that output of each commodity increases or decreases by a constant percentage per unit of time, the mutual proportions in which commodities are produced remaining constant. The economy changes in scale but not in composition" (p. 412).

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1) Boulding (1953) and perhaps Kuznets (1966) would tend, however, to view causality running the reverse course from development to balance/imbalance.

2) Hirschman also considers a causal link between imbalance and decision making. A celebrated example of decision making that is facilitated by imbalance is the sequence of shortage-surplus of "social overhead capital" and "directly productive activities".

This criterion is also termed Von Neumann's "uniformity notion" of growth (Champernowne, 1945-46).

A high degree of dispersion of sectoral growth rates from the overall rate of growth of an economy would define a high index of imbalance. In turn, a positive relationship of some "index of imbalance" with the observed rates of economic growth over a time period[1)] would constitute rejection of the balanced growth hypothesis. The following indices have been employed in the studies under review:

Yotopoulos-Lau (1970):

$$\bar{V} = \frac{1}{G}\sqrt{\sum_{i=1}^{n} (g_i - G)^2/n} \qquad (7.1)$$

$$V^* = \frac{1}{G}\sqrt{\sum_{i=1}^{n} w_i\,(g_i - G)^2} \qquad (7.2)$$

$$V' = \frac{1}{G}\sqrt{\sum_{i=1}^{n} w_i\,(g_i - E_iG)^2} \qquad (7.3)$$

---

1) For the test of the hypothesis, the theory of balanced/unbalanced growth fails to spell out an applicable time interval. In the studies by Swamy (1967) and Yotopoulos-Lau (1970) the time period studied is the same. It refers to 1948-60 within which three sub-periods are also distinguished. Further, data sources utilized are also identical.

Swamy (1967):

$$V_a = \sqrt{\sum_{i=1}^{k} (g_i - \hat{g}_i)^2 / k} \qquad (7.4)$$

$$V_b = \sum_{i=1}^{k} \left| g_i - \hat{g}_i \right| / k \qquad (7.5)$$

$$V_{aie} = \sqrt{\sum_{i=1}^{k} (g_i - GE_i)^2 / k} \qquad (7.6)$$

$$V_{bie} = \sum_{i=1}^{k} \left| g_i - GE_i \right| / k \qquad (7.7)$$

The symbols are:

- V's - various coefficients of variation.
- g_i - i-th sector's rate of growth.
- $\hat{g}_i$ - expected rate of growth of sector i.
- G - average rate of growth of a country.
- w_i - share of sector i.
- E_i - total income elasticity of demand for sector i's products.
- n,k - number of sectors.

Equations (7.1) and (7.2) in Yotopoulos-Lau's study and equations (7.4) and (7.5) in Swamy's deal with the 'uniformity notion' of growth. A $\overline{V}$ or V^* (or V_a; V_b) index of zero implies that the growth rate of each sector was equal to the overall growth rate in GDP for a specific country. Equation (7.3) in the former study and equations (7.6) and (7.7) of the latter refer to the 'elasticity version' of balanced growth due to Nurkse

(1961). It stipulates the creation of supply's own demand with the added proviso: " ... that supply is properly distributed among different commodities in accordance with consumer's wants. An increase in consumable output must advance along an expansion path determined by the income elasticity of consumer demand for its (the sector's) product (p. 250-251)". A V' index of zero indicates a change in scale in the economy proportional to the elasticity of demand for the output of each sector. A similar explanation applies to indexes V_{aie} and V_{bie}.

Swamy tested the balanced/unbalanced growth hypothesis by correlating the resulting indices with the overall rates of growth of an international cross section of countries. His findings support the unbalanced growth thesis. Yotopoulos-Lau also investigate the existence of a relationship between the indices of imbalance - equations (7.1) to (7.3) - and the overall rates of growth in GDP for the same sample of countries. They report the existence of an inverse relationship between sectoral variability and the rate of growth which implies that high sectoral imbalance is associated with low overall rates of growth. Their findings thus contradict the unbalanced growth hypothesis.

Even though the indices used by Yotopoulos-Lau (1970) are superior to those used by Swamy (1967)[1] they still ignore the important

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1) Inappropriate definition of sectoral imbalance (in terms of standard deviation and mean absolute deviation) used by Swamy for inter-country comparisons is cited by Yotopoulos-Lau as the main reason for the superiority of their properly defined indices.

effects of economic linkages, backward and forward, inherent in an interdependent economic system. The degree of balance/imbalance of an economy can be better understood only if the indices in question are constructed such that they capture these linkages.

A recent study by Yotopoulos-Nugent (1973) fills this void. Having modified the extreme version of Hirschman's (1958) linkage hypothesis[1)] they have proposed a linkage-balanced growth version. Their proposal considers a maximum degree of imbalance. It also provides that there should be a limit that the growth of a sector cannot exceed, no matter how high its linkage index, without adverse effects. Still adhering to the Yotopoulos-Lau (1970) definition of sectoral imbalance in terms of the deviation of sectoral growth rates from the overall rate of growth, they consider a maximum degree of imbalance that also reflects the sectoral linkage index. In this case, a sector grows differentially from other sectors due precisely to existing differences in linkage indices, all other factors appropriately weighted. This is what they term the "balanced-growth version of the linkage hypothesis".

Linkage-balance indices have been prepared by Yotopoulos-Nugent (1973) according to the following formulation:

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1) The extreme version of Hirschman's hypothesis prescribes that countries that allot high priority to high linkage industries would have a historical record of higher rates of growth than would countries that assign low priority to high linkage industries.

$$V_{Li} = \frac{1}{G_i}\sqrt{\sum_{j=1}^{n} (g_{ij} - C_{.j}G_i)^2/n} \qquad (7.8)$$

where:

- n - number of sectors.
- g_{ij} - sectoral growth rate of sector j in country i.
- $C_{.j}$ - total linkage index[1)] of sector j.
- G_i - overall growth rate in country i.

Equation (7.8) states that country i's growth is linkage-balanced when each sectoral growth rate varies in proportion to that sector's total linkage index. The formulation of indices in equation (7.8) when compared with those of previous studies reveals the following improvements: (a) adjustment has been made for differences among countries in the overall growth rate; and (b) the variance is computed not in terms of the deviations in g_{ij} from G_i but in terms of the deviations in g_{ij} from G_i weighted by the total linkage index $C_{.j}$.

1) Yotopoulos-Nugent (1973) in their formulation regard $C_{.j}$ as a total linkage index obtained by summing across rows of the inverse matrix C. We, however, regard it as similar to a backward linkage effect (cf. chapter 3).

7.2 SECTORAL BALANCE/IMBALANCE IN THE CANADIAN ECONOMY, 1961-70

The empirical underpinnings of the balanced/unbalanced growth thesis indicate that the formulated criterion of balance/imbalance depends on the degree of dispersion of sectoral growth rates from the overall rate of growth of an economy over a certain time period. Sectoral linkage effects can also be incorporated into this formulation to test the linkage-balance hypothesis (Yotopoulos-Nugent, 1973). Previous studies investigated cross-sectional differences in growth patterns among a number of countries. We herein apply some of the indices used in these studies to the analysis of sectoral balance/imbalance during 1961-70 in one country, Canada. The following formulation is considered:[1)]

$$V^{*}_{YLt'} = \left| g_i^{t'} - G^{t'} \right| \qquad (7.9)$$

$$V^{*}_{YNt'} = \left| g_i^{t'} - C_{.j} G^{t'} \right| \qquad (7.10)$$

where:

$g_i^{t'}$ - average sectoral growth rates for the whole period 1961-70.

$G^{t'}$ - overall average growth rate of GDP for the whole period 1961-70.

$C_{.j}$ - sectoral linkage index as defined previously

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1) A close scrutiny of equations (7.9) and (7.10) would reveal that they disaggregate the additive components of the indices described in equations (7.1) and (7.8) respectively.

Indices based on equations (7.9) and (7.10) would determine which industries have grown substantially differently from the overall rate of growth.

The data required are, for the period 1961-70, the sectoral growth rates (g_i); overall growth rates of GDP (G); and sectoral linkage indexes ($C_{.j}$). Sectoral growth rates for the period 1961-66 were obtained from published I-O tables.[1] For the years 1967-70 these have been obtained from unpublished information.[2] Overall growth rates of GDP are based on published information from the National Income and Expenditures Accounts.[3]

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1) Canadian Statistical Review, February 1975, Ottawa, The level of aggregation used in our study (75 industries; 115 commodities) differs from the published sources. It is, however, similar to the one used in the CANDIDE model and that being maintained at Statistics Canada.

2) Estimates prepared by the Structural Analysis Division of Statistics Canada as part of the Annual Matrices Projection Project.

3) GDP (at market prices) is calculated as GDP at factor cost plus indirect taxes less subsidies. For the years 1961-70 GDP of the Canadian economy (in current $) and the rates of growth are:

	GDP (000 current $)	Growth rate
1961	40,369,692	
1962	43,369,858	0.089
1963	47,007,495	0.069
1964	51,254,525	0.090
1965	56,688,511	0.106
1966	63,208,962	0.115
1967	67,678,000	0.071
1968	73,837,000	0.091
1969	80,991,000	0.097
1970	86,762,000	0.071

$G^{t'} = 0.799/9 = 0.0887$

(footnote continued on p.110)

Source: See Statistics Canada catalogue 13-502 (Occassional) National Accounts, Income and Expenditure 1926-56. Figures reported have been obtained from the historical revisions of National Income and Expenditure Accounts released in October 1972 by Statistics Canada.

7.3 DISCUSSION OF FINDINGS

Results of the computations based on equations (7.9) and (7.10) are shown in Table B.1, appendix B. Column (1) of this table shows sectoral average growth rates while columns (2) and (3) list values of the variables used in the equations. In reporting these results we have not suppressed their respective signs. Values of $C_{.j}$ are shown in column (4).

An examination of column (2) of Table B.1, appendix B, reveals that 60 industries out of a total of 72 examined[1)] show positive deviations from the average overall rate of growth (of 0.0887) during the period 1961-70. Of these there were 10 industries that showed deviations in excess of 0.10. These are shown in Table 7.1 below:

TABLE 7.1 INDUSTRIES SHOWING DEVIATIONS IN EXCESS OF 0.10 FROM THE OVERALL RATE OF GROWTH: 1961-70

Industries.	$g_i^{t'}$	$g_i^{t'} - G^{t'}$
29.	0.2129	0.1242
31.	0.4411	0.3524
32.	0.2506	0.1619
34.	0.2261	0.1374
36.	0.8179	0.7292
45.	0.2155	0.1268
48.	0.2433	0.1546
50.	0.2002	0.1115
52.	0.2092	0.1205
75.	0.7277	0.6390

1) For the period 1967-70, due to non-availability of data, growth rates for three industries, pulpmaking (no. 22), papermaking and other activities (no. 23), and dummy, transport margins (no. 74) could not be computed. Hence these are not considered in this part of the study.

It may be seen from this table that the miscellaneous transport equipment industry (no. 36) shows the highest deviation of 72.92 per cent. The next highest deviation of 63.90 per cent is recorded for the dummy: other industry (no. 75) which is followed by the truck bodies and trailer industry (no. 36) with a deviation of 35.24 per cent.

Column (3) of Table B.1, appendix B, shows the deviation of sectoral growth rates from the overall rate of growth adjusted for sectoral linkages. It appears that 22 industries (out of a total of 72) show deviations in excess of 0.10. Three industries exhibit deviations in excess of 0.20. Large positive deviations are recorded for the miscellaneous transport equipment industry (no. 36) with a deviation of 61.26 per cent and for the dummy: other industry (no.75) with a deviation of 47[illegible] per cent.

CHAPTER 8.

SUMMARY, CONCLUSIONS AND IMPLICATIONS.

This study has been concerned primarily with the analysis of structural change in the Canadian economy. Changes in gross production and intermediate outputs have been estimated on the basis of I-O tables for the years 1961 and 1966. It has been demonstrated that these changes arise not only from changes in the bill of final demand but are also due to changes in the coefficients of production. Structural change has also been analyzed on the basis of inverse matrices, and "summary measures" of change developed by Rasmussen (1957) have been employed. In addition, changes in the direct coefficients of the technology matrix B as precursors of change have been analyzed. As a by-product of the major endeavour in this study, the I-O framework has been utilized to explore the notion of 'linkages'. Having determined backward and forward linkages in the economy we have used them in the determination of key industries. Key industries have also been determined on the basis of final demand. Results of the two identification procedures have been contrasted. Secondly, the empirical content of the concept of balance/imbalance in growth theory has been applied to determine sectoral balance/imbalance in the Canadian economy during the 1960's. Following an earlier study (Yotopoulos-Nugent, 1973), we have used sectoral linkage indices in conjunction with the concept of imbalance to determine linkage-balance industries in the Canadian economy.

Results of the analysis reveal that from 1961 to 1966 changes in the final demand bill resulted in a change of $38.8 billion in total output. Since the change in final demand does not impact on all the

75 industries examined to the same extent, a wide range of change in individual industries' gross production has been observed. Highest absolute increases were obtained in finance, insurance and real estate; retail trade; wholesale trade; agriculture; metal fabricating and non-residential construction. The largest negative impact of coefficient change on gross production between 1961 and 1966 occurs in the coal industry. This reduction is interpreted as a result of changing inter-industry relationships and implies that change in technology would have made it possible to deliver the same 1961 bill of final demand with less production in 1966 than in 1961.

The analysis of changes in intermediate output levels highlights the changing industrial specialization in the Canadian economy. It demonstrates that the total value of intermediate outputs (inputs) required to satisfy the 1966 bill of final demand declined slightly over time. This overall tendency, however, is not shared by all industries. At the group level (cf. chapter 4), requirements from all groups but metal-working have been declining. Metal-working inputs rise as the complexity of the products increases, and as specialization within the metal-working group grows. Among industries whose intermediate deliveries were most affected by structural change, urban transit systems (no. 55) and motor vehicles (no. 30) show strong positive change of 342.9 per cent and 176.8 per cent respectively. However, pipelines (no. 54) and miscellaneous transport equipment (no. 36) registered decreases of 42.4 per cent and 33.3 per cent, respectively. The general conclusion is drawn that overall intermediate output levels observed for the Canadian economy tend to be smaller with newer than with older technology as measured by inverse coefficients. This result is in contrast to the findings of Carter (1970) who, for the U.S. economy, observed a slight increase (dollar volume, in constant prices) of intermediate inputs with newer than with older techniques of production. Her interpretation of this paradox is that increased volume of intermediate inputs means an increase in specialization and may not be construed as a deterioration of technology.

While analyzing structural change in the above manner it became obvious that, in fact, we were considering changes in the elements of the inverse matrix. Rasmussen (1957) had shown in his analysis of the Danish economy that the inverse matrix itself can be used to obtain "summary measures" to describe structural change. Following his formulation we prepared various indices of structural change for the Canadian economy. In almost all cases, when these indices of structural change are compared over the two years in question, it is found that their values tend to be smaller in the current year (1966) than in the preceding year (1961). This tends to support the earlier observation that as years pass technological efficiency improves in the sense that requirements placed on the system are met with lesser intermediate inputs to produce them.

Structural change analyzed thus far, relying as it does on the inverse matrices, captures changes in the coefficients for primary as well as secondary impacts associated with a bill of final demand. It is nonetheless probable that these changes may either be reinforcing or offsetting, thus blurring the true picture of the magnitude and direction of change. To mitigate this shortcoming we analyzed direct coefficients themselves -- that is, coefficients of the technology matrix B. Analysis of the magnitude of change in direct coefficients between 1961 and 1966, at the industry level, reveals that small changes occur in 60 out of the 75 industries examined. The most pronounced changes (0.36+), however, occur in three manufacturing industries (grain mill; paper-making; and railroad rolling stock); in metal mines; in pipeline transport; in radio and T.V.; and in two utilities (gas and water). Using weighted indices to measure the direction of change, at the industry level, we find that on the average input ratios in most industries increase slightly (0.4 per cent). However, in each individual industry most of them are increasing while others are decreasing. The ratios for 36 industries (out of 75) are decreasing. This observation points out the question of product substitution in its relation to structural change.

We extended this analysis of direct coefficient change by conducting a cell-by-cell analysis both at the industry and commodity level. Analysis at the industry level reveals that there is a tendency for the majority of industries consuming non-primary intermediate inputs to show coefficient changes of the same direction as the overall change. This is true for 50 of the 75 industries examined. Similarly, there is a tendency for the majority of the customers of a given commodity to show direct coefficient changes of the same direction as the overall change. Seventy-six of the 105 commodities studied showed coefficient changes of the same direction (30 negative and 46 positive) as the average for the majority of their individual consuming industries.

The indices of structural change based on inverse matrices found a useful application in the analysis of 'linkages'. It has been shown that the index of power of dispersion defined in equation (3.19) is analogous to Hirschman's backward linkage effect, whereas the index of sensitivity of dispersion defined in equation (3.20) corresponds to the forward linkage effects. In conjunction with their variability measures these linkages have been employed to determine key industries in the Canadian economy. Results of this analysis show that the number of key industries identified is consistently larger in 1966 than in 1961 for all three indices used. Another interesting feature is that key industries identified on the basis of index III are also key industries identified on the basis of indexes I and II. In 1961 such key industries included machinery (no. 29), and chemical products (no. 41); in 1966 these were paper converters (no. 24), machinery (no. 29), chemical products (no. 41), and miscellaneous manufactures (no. 42).

Key industries have also been identified on the basis of final demand considerations. For both years, according to weighted indices (for all three matrices examined), there are ten industries that consistently qualify as key industries. These are: other food and soft drinks (no. 12), papermaking and other activities (no. 23), primary non-ferrous (no. 27), electrical products (no. 37), wholesale trade (no. 65), hotels and restaurants (no. 71), other services (no. 73), and dummy (no. 74). Results obtained on the basis of these two criteria tend to show that key industries in an economy can neither be defined nor identified uniquely. In addition to the definition employed in this study other definitions are feasible, such as maximizing employment subject to given increase in gross output levels.

Sectoral balance/imbalance in the Canadian economy has been analyzed on the basis of an operationally defined concept of balance/imbalance by Swamy (1967) and Yotopoulos-Lau (1970). Also, an extension of this concept suggested by Yotopoulos-Nugent (1973) has been tried with Canadian data. This extension, by modifying Hirschman's (1958) extreme version of the linkage-hypothesis, proposes a linkage-balanced growth version. Indices measuring sectoral balance/imbalance were prepared by disaggregating the additive components of the formulations used in previous studies. We have identified, for the period as a whole, those industries that contributed strongly to imbalance; and have also determined those industries that show deviations from the postulated linkage-balance proportions. Of the 60 (out of a total of 72) industries showing positive deviations from the overall rate of growth we found 10 industries that showed deviations in excess of 0.10. Included among these are: miscellaneous transport equipment (no. 36), with the highest deviation of 72.9 per cent, followed by truck bodies and trailer (no. 31) with a deviation of 35.2 per cent. There were 22 industries that deviated from the linkage balance by more than 0.10. Of these, three exhibit deviations in excess of 0.20. They are: miscellaneous transport equipment (no. 36), dummy: other (no. 75), and truck bodies and trailer (no. 31) with 61.3 per cent, 47.3 per cent, and 22.7 per cent deviations, respectively.

One notices a lag of several years between the years of reference and the actual publication of I-O tables pertaining to that year. For many uses of I-O tables this time lag is not a serious deficiency since the assumption of stability of I-O coefficients over a short period of time is generally accepted. The problem is compounded, however, when one constructs an annual econometric model around an input-output table. The lack of annual input-output tables encompassing the sample period over which the econometric model is estimated leads to arbitrary procedures whereby the results of the I-O model are adjusted. Such a practice violates identities inherent in the I-O system. One of the ways to overcome this shortcoming is to project the missing I-O tables. Methods, such as the Statistical Correction Method (Tilanus, 1966) and RAS (Stone, 1963) are available to do just that. Since these are operationally demanding, our analysis of changes in the coefficients of technology matrix B provides a convenient way of studying changes. The information so obtained can be used to update those coefficients that show large deviations.

Prior to the establishment of an industrial strategy, or a revision of an existing one, there is a case for a preliminary analysis of the interindustry relationships on which such decisions can be based. The analysis of 'key' industries presented in this study could serve as a useful tool in this regard. Following Rasmussen (1957) it has been shown to provide indices by which to gauge the relative importance of a sector according to its interindustry linkage effects. The underlying goal is the identification of those key industries which have a high degree of interdependence with other industries in the economy.

The crucial feature of a key industry has been described as its ability to call forth a relatively large increase in the output of sectors when final demand for its products is increased, while at the same time its output must expand more than the average to meet the final demand of other sectors. In identifying these industries one gains a fuller appreciation of the pattern of sectoral interdependence in the economy.

APPENDIX A.

INDUSTRY AND COMMODITY CLASSIFICATION USED IN THE STUDY.

INDUSTRIES.

1. Agriculture.
2. Forestry.
3. Fishing.
4. Metal mines.
5. Coal.
6. Petroleum & Gas Wells.
7. Non-metal mines.
8. Meat products.
9. Dairy Products.
10. Fish Products.
11. Grain mills.
12. Other food and soft drinks.
13. Alcoholic beverages.
14. Tobacco.
15. Rubber.
16. Leather.
17. Textiles.
18. Clothing, knitting.
19. Wood.
20. Furniture.
21. Pulp and paper dummy.
22. Pulpmaking.
23. Papermaking and other activities.
24. Paper converters.
25. Printing and publishing.
26. Iron and steel.
27. Primary nonferrous.
28. Metal fabricating.
29. Machinery.
30. Motor vehicles.

31. Truck bodies and trailers.
32. Parts and accessories.
33. Aircraft and parts.
34. Railroad rolling stock.
35. Shipbuilding and repair.
36. Miscellaneous transport equipment.
37. Electrical products.
38. Nonmetallic mineral products.
39. Petroleum and coal products.
40. Industrial chemicals.
41. Chemical Products.
42. Miscellaneous manufactures.
43. Repair construction.
44. Residential construction.
45. Nonresidential construction.
46. Roads, highway and airstrip construction.
47. Gas and oil facility construction.
48. Dams and irrigation projects.
49. Railway, telephone, telegraph construction.
50. Other engineering construction.
51. Other construction activities.
52. Air transport.
53. Railway transport.
54. Pipelines.
55. Urban transit systems.
56. Water transport.
57. Motor transport and other.
58. Storage.
59. Radio and TV broadcasting.
60. Telephone and telegraph.
61. Post Office.
62. Electric Power.
63. Gas

64. Water and other.
65. Wholesale trade.
66. Retail trade.
67. Finance, insurance, real estate.
68. Owner-occupied dwellings.
69. Education and related services.
70. Health and Hospitals.
71. Hotels and restaurants.
72. Business services.
73. Other services.
74. Dummy, transport margins.
75. Dummy: other.

COMMODITIES:

1. Grain.
2. Other agriculture.
3. Forest products.
4. Fishing and trapping products.
5. Crude petroleum.
6. Natural gas.
7. Sulphur.
8. Coal.
9. Iron ore.
10. Asbestos.
11. Bauxite and aluminum.
12. Other metals.
13. Other non-metallic minerals.
14. Meat products.
15. Dairy products.
16. Fish products.
17. Feed.
18. Wheat flour.
19. Other grain mill products.

20. Bakery products.
21. Soft drinks.
22. Other food products.
23. Alcoholic beverages.
24. Tobacco.
25. Tires and tubes.
26. Other rubber products.
27. Leather products.
28. Yarn and man-made fibres.
29. Fabrics.
30. Textile products.
31. Clothing.
32. Lumber and plywood
33. Wood products.
34. Furniture and fixtures.
35. Pulp and paper dummy commodity.
36. Pulp
37. Newsprint.
38. Other paper stock.
39. Industrial paper products.
40. Household paper products.
41. Printed matter
42. Iron and steel products.
43. Aluminum products.
44. Copper and copper alloy.
45. Nickel products.
46. Other non-ferrous products.
47. Metal fabricated products.
48. Agricultural machinery.
49. Other industrial machinery.
50. Passenger cars.
51. Other motor vehicles.
52. Truck bodies and trailers.

53. Motor vehicle parts and acessories.
54. Aircraft and parts.
55. Railroad rolling stock.
56. Ships and repairs.
57. Miscellaneous transport equipment.
58. Appliances.
59. Other electrical equipment.
60. Cement and concrete products.
61. Other non-metallic mineral products.
62. Fuels, petroleum.
63. Other petroleum and coal products.
64. Industrial chemicals.
65. Fertilizers.
66. Pharmaceuticals.
67. Other chemical products.
68. Scientific equipment.
69. Plastic products.
70. Other manufactured products.
71. Residential dwellings.
72. Non-residential dwellings.
73. Roads, highways, airstrips.
74. Gas and oil facilities.
75. Dams and irrigations projects.
76. Railway, telephone, telegraph installations.
77. Other engineering structures.
78. Repair construction.
79. Air transportation.
80. Railway transportation.
81. Pipeline transportation.
82. Urban transit.
83. Water transport.
84. Motor transport and other.
85. Storage.
86. Transportation margins.

87. Radio and TV broadcasting.
88. Telephone and telegraph communications.
89. Postal services.
90. Electric power.
91. Gas distribution.
92. Water and other utilities.
93. Wholesale margins.
94. Retail margins.
95. Finance, insurance, and real estate.
96. Imputed rent.
97. Education.
98. Hospitals and health.
99. Hotels, restaurants, etc.
100. Recreational services.
101. Personal services.
102. Business services.
103. Repair services.
104. Other services.
105. Dummy.
106. Non-competing imports.
107. Balance of payments adjustment.
108. Government goods and services.
109. Indirect commodity taxes.
110. Subsidies.
111. Other indirect taxes.
112. Wages and salaries.
113. Supplementary labour income.
114. Net income of unincorporated business.
115. Surplus.

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APPENDIX B.

Table B.1: Sectoral Growth Rates, Imbalance (Balance) and Linkages of the Canadian Economy: 1961-70

Industry	(1) $g_i^{t'}$	(2) $g_i^{t'} - G^{t'}$	(3) $g_i^{t'} - C_{.j} \, G^{t'}$	(4) $C_{.j}$
1.	0.0589	- 0.0298	- 0.1037	1.8320
2.	0.0712	- 0.0175	- 0.1038	1.9718
3.	0.0818	- 0.0069	- 0.0826	1.8516
4.	0.0868	- 0.0019	- 0.0635	1.6929
5.	0.1080	0.0193	- 0.0416	1.6846
6.	0.1535	0.0648	0.0094	1.6238
7.	0.1263	0.0376	- 0.0332	1.7959
8.	0.1163	0.0276	- 0.1255	2.7233
9.	0.0711	- 0.0176	- 0.1645	2.6535
10.	0.1061	0.0174	- 0.1158	2.4989
11.	0.0959	0.0072	- 0.1569	2.8473
12.	0.0899	0.0012	- 0.1226	2.3932
13.	0.0888	-	- 0.0972	2.0951
14.	0.0766	- 0.0121	- 0.1597	2.6611
15.	0.1203	0.0316	- 0.0733	2.1804
16.	0.0503	- 0.0384	- 0.1716	2.4990
17.	0.1092	0.0205	- 0.1040	2.4011
18.	0.0859	- 0.0028	- 0.1316	2.4502
19.	0.1194	0.0307	- 0.0866	2.3197
20.	0.1418	0.0531	- 0.0582	2.2524
21.	0.0848	- 0.0039	- 0.0496	1.5143
22.**	--	--	--	--
23 **	--	--	--	--
24.	0.1430	0.0543	- 0.1078	2.8243
25.	0.0912	0.0025	- 0.1034	2.1917
26.	0.1455	0.0568	- 0.0477	2.1751
27.	0.1073	0.0186	- 0.1479	2.8733
28.	0.1587	0.0700	- 0.0444	2.2882
29.	0.2129	0.1242	0.0121	2.2612
30.	0.1419	0.0532	- 0.1177	2.9239
31.	0.4411	0.3524	0.2270	2.4104
32.	0.2506	0.1619	0.0307	2.4767

Industry	(1) $g_i^{t'}$	(2) $g_i^{t'} - G^{t'}$	(3) $g_i^{t'} - c_{.j} G^{t'}$	(4) $c_{.j}$
33.	0.0994	0.0107	- 0.0990	2.2351
34.	0.2261	0.1374	0.0009	2.5361
35.	0.1186	0.0299	- 0.0661	2.0812
36.	0.8179	0.7292	0.6126	2.3124
37.	0.1473	0.0586	- 0.0641	2.3815
38.	0.1299	0.0412	- 0.0582	2.1192
39.	0.0224	- 0.0663	- 0.1959	2.4579
40.	0.1249	0.0362	- 0.0624	2.1099
41.	0.1035	0.0148	- 0.1177	2.4922
42.	0.1461	0.0574	- 0.0522	2.2329
43.	0.1007	0.0120	- 0.0529	1.7300
44.	0.1301	0.0414	- 0.0609	2.1518
45.	0.2155	0.1268	0.0182	2.2227
46.	0.1829	0.0942	- 0.0024	2.0870
47.	0.0536	- 0.0351	- 0.1473	2.2631
48.	0.2433	0.1546	0.0382	2.3098
49.	0.1076	0.0189	- 0.1053	2.3986
50.	0.2002	0.1115	- 0.0136	2.4077
51.	0.1493	0.0606	0.0052	1.6228
52.	0.2092	0.1205	0.0440	1.8607
53.	0.0733	- 0.0156	- 0.0698	1.6120
54.	0.1279	0.0392	0.0141	1.2819
55.	0.1033	0.0146	- 0.0129	1.3087
56.	0.0941	0.0054	- 0.0687	1.8342
57.	0.1289	0.0402	- 0.0242	1.7247
58.	0.1102	0.0215	- 0.0307	1.5868
59.	0.1813	0.0926	- 0.0066	2.1164
60.	0.1364	0.0477	0.0217	1.2915
61.	0.1250	0.0363	- 0.0184	1.6144
62.	0.1002	0.0114	- 0.0123	1.2674
63.	0.1505	0.0618	0.0419	1.2221
64.	0.1547	0.0660	- 0.0350	2.1366
65.	0.1480	0.0593	- 0.0018	1.6879
66.	0.1014	0.0127	- 0.0459	1.6586

Industry	(1) $g_i^{t'}$	(2) $g_i^{t'} - G^{t'}$	(3) $g_i^{t'} - C_{.j}\, G^{t'}$	(4) $C_{.j}$
67.	0.1195	0.0308	- 0.0133	1.4962
68.	0.0951	0.0064	- 0.0147	1.2374
69.	0.1318	0.0431	- 0.0230	1.7436
70.	0.1429	0.0542	0.0071	1.5292
71.	0.1309	0.0422	- 0.0401	1.9259
72.	0.1827	0.0940	0.0575	1.4103
73.	0.1578	0.0691	0.0048	1.7219
74.**	--	--	--	--
75.	0.7277	0.6390	0.4723	2.8796

** For the period 1967-70, growth rates for these industries could not be computed due to unavailability of data. These are, therefore, not reported here.

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