WORKING PAPER

THE KNOWLEDGE-BASED ECONOMY: SHIFTS IN INDUSTRIAL OUTPUT

Working Paper Number 15
January 1997

Industry Canada Industrie Canada

WORKING PAPER

THE KNOWLEDGE-BASED ECONOMY: SHIFTS IN INDUSTRIAL OUTPUT

by Surendra Gera, Industry Canada,
and Kurt Mang, Department of Finance

Working Paper Number 15
January 1997

Aussi disponible en français

Canadian Cataloguing in Publication Data

Gera, Surendra

The knowledge-based economy : shifts in industrial output

(Working paper; number 15)
Text in English and French on inverted pages.
Title on added t.p.: L'économie du savoir et l'évolution de la production industrielle
Includes bibliographical references.
ISBN 0-662-62821-7
Cat. no. C21-24/16-1997

1. Industries -- Technological innovations -- Canada.
2. High technology industries -- Canada.
3. Industrial productivity -- Canada.
4. Information technology -- Canada.
5. Canada -- Economic conditions -- 1971-1991.
I. Mang, Kurt.
II. Canada. Industry Canada.
III. Title.
IV. Series: Working paper (Canada. Industry Canada)

HC79.I55G47 1997 338'.064'0971 C97-980025-0

ACKNOWLEDGEMENTS

An earlier version of this paper was presented at the Canadian Economics Association Meetings, Montreal, May 31-June 2,1996; at the Expert Workshop on Technology, Productivity and Employment: Macroeconomic and Sectoral Evidence, Organisation for Economic Co-operation and Development, Paris, June 19-20, 1995; and at the Eleventh Annual Meeting of the International Input-Output Association, New Delhi, India, November 26-December 1, 1995.

Funding for the project was provided by Industry Canada and Human Resources Development Canada. We are especially thankful to Ogie Choi for her excellent research assistance. We thank Pierre Mercier of the Input-Output Division of Statistics Canada for providing invaluable support and insights at all stages of our research. We are indebted to Denis Gauthier, Kevin Lynch, Munir Sheikh, Serge Nadeau, Someshwar Rao, Haider Saiyed, James Kalwarowsky, Frank Lee, Handan Has, Clifton Lee-Sing, and two anonymous referees for their helpful comments. Thanks are also due to Caroline Farmer and Patrick Taylor for assistance in the preparation of this paper.

The list of titles available in the *Research Publications Program* and details on how to obtain copies can be found at the end of this document. Abstracts of Industry Canada research volumes, working papers, occasional papers, discussion papers and the full text of our quarterly newsletter, MICRO, can be accessed via STRATEGIS, the Department's online business information site, at http://strategis.ic.gc.ca.

Comments should be addressed to:
Someshwar Rao
Director, Strategic Investment Analysis
Micro-Economic Policy Analysis
Industry Canada
235 Queen Street, 5th Floor, West Tower
Ottawa (Ontario) K1A 0H5
Tel: (613) 941-8187 Fax: (613) 991-1261 E-Mail: Rao.Someshwar@ic.gc.ca

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The authors analyze Canada's industrial structure over the period from 1971 to 1991, using Statistics Canada's input/output model. Though largely based on previous work done by the Organisation for Economic Co-operation and Development (1992), this study employs more timely data and a finer industrial disaggregation (111 industries versus 33), and explores more closely the role played by the "new economy" industries – that is, those industries where innovation through the use of knowledge, technology and skills is the key to generating growth.

The study examines the extent and nature of changes in the Canadian industrial structure by addressing four policy-related questions:

- What has been the *extent* of structural change in the Canadian economy? Which industries experienced growth? Which industries did not?
- Has the *pace* of structural change been accelerating?
- Is the Canadian economy becoming more *innovative*? Is it increasing its use of knowledge, technology, skills, etc.?
- What are the key *factors* driving this structural change: final domestic demand, exports, imports, or technical change (measured by changes in input/output coefficients)?

Our analysis has led to the following conclusions.

- ***Structural change is evident at the aggregate level and at the detailed industrial level.***

  The traditional sectors – primary resources, manufacturing, and construction – are losing a great deal of their importance in the economy relative to the service sector.

  The "engines of growth" in the Canadian economy – computers and office equipment; communication equipment and semiconductors; communication services; real estate and business services; community, social, and personal services; pharmaceuticals; electricity, gas, and water; and finance and insurance – have led the way throughout the 1971-91 period. There is surprisingly little movement among the growth leaders over time.

- ***Contrary to widespread belief, the speed of change in the economy does not appear to be accelerating.***

  The Canadian industrial structure is becoming increasingly knowledge-based and technology-intensive, with competitive advantage being rooted in innovation and ideas – the foundations of the new economy.

Industrial structural change is occurring in parallel with increases in knowledge intensity. The economy is moving up the knowledge intensity scale. Moreover, this shift has been apparent since the early 1970s.

High-knowledge industries dominated growth rankings over the most recent period (1986-91), with seven of the top ten growth industries belonging to the knowledge-intensive category.

Despite this superior performance, the Canadian business sector is still largely comprised of medium- and low-knowledge industries.

In the manufacturing, service, and resource sectors, those industries which require high-knowledge input consistently outperformed, on average, those with more modest knowledge requirements.

- ***The Canadian manufacturing sector is becoming more innovative through the use of high-technology and more advanced labour skills.***

  Structural change in the manufacturing sector occurs in parallel with changes in technological intensity, in the skill intensity of output, and in wage levels.

  From 1971 to 1991, high-technology industries in the manufacturing sector – those which spend a high proportion of their resources on research and development (R&D) – experienced higher growth rates than the sectoral average. During the same period, the relative importance of low-technology industries declined.

  Industries in the manufacturing sector that use higher labour skills have, over the period, increased their relative importance as compared to lower-skill industries.

  Over the period 1971-91, industries in the manufacturing sector that pay higher wages have been higher-growth industries.

- ***The service sector is also becoming more innovative.***

  The service sector has undergone much the same evolution, in terms of knowledge intensity, as has manufacturing: high-knowledge industries outpaced the growth of the service sector as a whole and of the overall business sector. So, too, have medium-knowledge services.

- ***While in the past domestic demand was the dominant factor influencing the growth of industries, trade is now becoming much more important. High-knowledge industries in the tradable sector seem to have benefited the most from export performance; low-knowledge industries have seen their relative decline hastened by import competition.***

Exports have been an increasingly important factor for change in high-technology manufacturing industries. Rising imports contributed to the loss of output share in low-technology industries. The same conclusion is reached in the case of those industries which tend to employ lower-skilled workers.

Within the manufacturing sector, high-wage industries are generally export-oriented. Changing trade patterns, at least during the 1980s, did not hurt those industries. However, import competition generally had net negative effects on medium- and low-wage industries.

For the service sector, the domestic market remains predominant. This is a reflection of the fact that services are not traded to the same extent as goods. Nonetheless, trade in services is growing in importance.

For both traditional and high-knowledge services, technical change has become more important.

- ***Structural change is also evident in the natural resource sector.***

  While the natural resource sector seems to be in general decline, a closer examination of industry-level data reveals the above-average performance of several industries that comprise this sector – namely, fishing and trapping, a low-knowledge industry; and such medium-knowledge industries as metal and non-metal mining, and mineral fuels.

  In the most successful resource industries, above-average performance is related to trade factors; most of these industries experienced strong growth despite low or even negative domestic-demand effects.

1. INTRODUCTION

The structures of the world's advanced industrial economies have been experiencing tremendous change over the past two decades. Events such as oil price shocks and major recessions have contributed greatly to this phenomenon, as have institutional changes such as the increasing liberalization of world trade and capital markets. The shift in consumer demand patterns from commodities to services and the progress and diffusion of technology have also been major contributors to the economic changes taking place in the world's wealthy countries.

Research shows that Canada has been no exception to these developments. Changes in structural trends among our trading partners have put pressure on our own industrial structure, and major policy initiatives introduced over the last decade have placed additional demands on many Canadian industries, leading some to decline and others to grow. It has been argued that the 1980s marked a fundamental shift in the nature of wealth generation in Canada and that a further rethinking of our economic policies is therefore in order (Harris, 1993). Beck (1992) and others have emphasized the increasing importance of high value-added, knowledge-based industries in the future "innovative economy."[1]

Most of the research to date has been conducted at the macro level. Our approach in this paper takes a micro perspective – an industry-by-industry analysis in the tradition of a recent study by the Organisation for Economic Co-operation and Development (OECD), *Structural Change and Industrial Performance* (1992).

The OECD study examined the sectoral composition of output in seven major member countries – Australia, Canada, France, Germany, Japan, the United Kingdom and the United States – with a view to quantifying the extent and direction of structural change that has taken place in individual economies during the 1980s. The technique used for this analysis is input/output decomposition analysis, an approach that reflects the logical structure of an input/output model. It relates changes in an industry's output structure to the sources of change – namely, shifts in structure associated with domestic final demand, exports, imports of final and intermediate products, and technical change (as measured by changes in input/output coefficients).

Several interesting cross-country findings emerged from the OECD analysis for the period 1981-86:

- Services and high-technology manufacturing have gained large shares of output in all seven countries.
- Low-tech manufacturing, construction, natural resource, and some medium-tech manufacturing industries are in decline.
- Technical change has been an important determinant of structural change and industrial composition in all seven countries; in particular, it has been the predominant source of decline in low-tech manufacturing industries.

- Exports and imports have contributed significantly to the growth of high-technology industries and the decline of medium-tech manufacturers.
- Final domestic demand has been, on average, the predominant driving force behind the expansion of industries classified as high-growth activities.

Some findings pertained specifically to Canada:

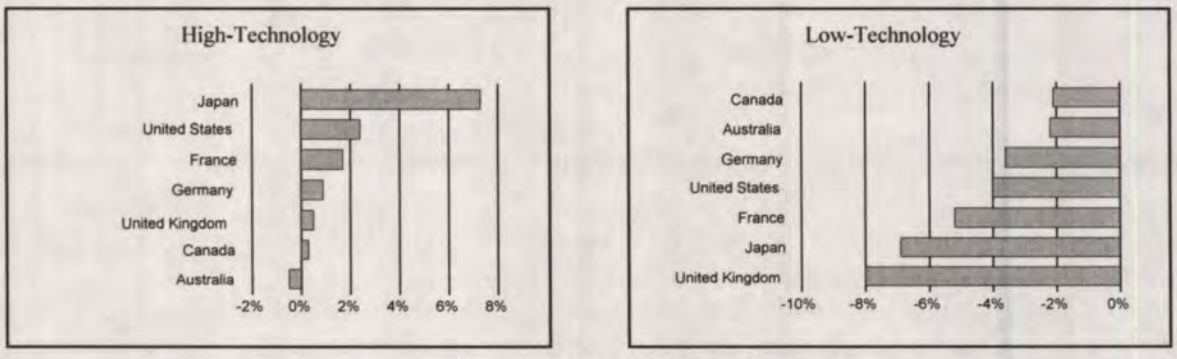
- The direction of structural change in Canada has been far from ideal. Canada (and Australia) have had relatively small changes in output shares into high-growth and out of low-technology manufacturing industries. Japan appeared to be closest to the ideal with respect to the direction of change of its industrial composition. Canada was one of only two countries experiencing gains in medium-tech manufacturing (Chart 1-1).

- Export-driven growth was more important in Canada than in most other countries. This resulted mainly from the performance of the motor vehicle industry and accounted for the share gains in medium-tech manufacturing.

In this study, we extend the OECD (1992) analysis for Canada, using Statistics Canada's national input/output data for three subperiods – 1971-81, 1981-86, and 1986-91. The study addresses the following questions:

- What has been the extent of structural change in the Canadian economy? Which industries experienced growth? Which industries did not?
- Has the pace of structural change accelerated?
- Is the Canadian economy becoming more innovative? Is the use of knowledge, technology, skills, etc. increasing?
- What are the key factors driving this structural change – final domestic demand, exports, imports, and/or changes in production techniques?

Chart 1-1
Change in Relative Output Shares, by Level of Technology Intensity, Seven Industrialized Countries, 1981-86



Source: OECD, 1992.

We employ a finer industry breakdown than does the OECD (111 industries versus 33) and base our results on a longer sample period. Most importantly, our work employs data up to 1991, whereas the OECD study used data no later than 1986. Thus a major goal here is to determine whether the patterns apparent in the OECD study have continued or changed since the mid-1980s. The OECD study found the direction of structural change in Canada to be "far from ideal"; we hope to establish whether this is still the case or whether Canada has started catching up to the industrial world's leading economies.

Unfortunately, the Statistics Canada input/output tables are not available on a consistent constant-dollar basis for the entire period 1971-91. Constant-dollar data are only available for three subperiods within this time span – 1971-81, 1981-86, and 1986-91 – with the 1986 data being evaluated in 1981 dollars but not in 1971 dollars, and the 1991 data being expressed in 1986 dollars, but not in 1971 or 1981 dollars. Calculations for all measures of change were done for the three subperiods.[2]

The study proceeds with an analysis of structural change at the aggregate and industry levels. We identify high-, low-, and negative-growth industries and investigate the pace of structural change occurring over time. Then, we seek to answer the question whether Canadian industry is becoming more innovative by looking at changes in the knowledge, technology, and skill intensity of industrial output. We also examine the demand-side factors that are driving the shifts in output. Finally, we present a summary and conclusions arising from our analysis.

2. CANADA'S CHANGING INDUSTRIAL STRUCTURE

What is the extent of structural change in the Canadian economy? Our analysis of this question focuses on three elements: change at the aggregate level; change at the individual industry level; and the pace of structural change.

Change at the Aggregate Level

The output structure of the Canadian economy, like that of other industrialized economies, has experienced steady change in recent decades. Canada enjoyed relatively rapid output growth in the 1970s: real gross output grew at an annual rate of 4.1 percent between 1971 and 1981, but declined thereafter. While all four major industrial sectors (primary, manufacturing, construction, and services) have experienced positive output growth rates since the 1970s, only growth in services outpaced the growth of the economy as a whole (Table 2-1).

The results of diverging sectoral growth rates are seen in the evolution of absolute sectoral shares of gross output over time (Table 2-2). While the primary, manufacturing, and construction sectors all saw their shares of output decline over each subperiod, services gained in this respect, accounting for almost 45 percent of gross output by 1991 (in 1986 constant dollars).

Table 2-1
Growth Rate of Gross Output, by Major Sector, 1971-91[1]

	1971-81	1981-86	1986-91
Primary	1.8	2.4	2.0
Manufacturing	3.3	2.2	0.6
Construction	3.6	-0.2	2.0
Services	5.6	3.5	3.2
Overall Business Sector	4.1	2.4	2.0

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 2-2
Gross Output Shares, by Major Sector, Selected Years, 1971-91[1]

	1971-81		1981-86		1986-91	
	1971	1981	1981	1986	1986	1991
Primary	8.6	6.9	11.3	11.3	8.9	8.9
Manufacturing	40.8	37.6	39.5	39.0	38.1	35.6
Construction	13.0	12.8	12.6	10.9	10.9	10.9
Services	37.5	42.7	36.6	38.7	42.0	44.7
Overall Business Sector	100.0	100.0	100.0	100.0	100.0	100.0

1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 2-3
Changes in Relative Output Shares, by Major Sector, 1971-91[1]

	1971-81	1981-86	1986-91
Primary	-1.9	-0.04	0.0
Manufacturing	-3.2	-0.5	-2.5
Construction	-0.3	-1.6	-0.1
Services	5.3	2.2	2.6

1 Percentage points, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 2-3 summarizes the changes in the relative gross-output shares of the major industrial sectors, which measure sectoral deviations from the average output growth of the economy as a whole. An industry that grows faster than the average will experience a net increase in output share; the converse is also true.

Clearly, the most dramatic decline has been in the manufacturing sector, with an average fall in output share of over 3 percentage points in the 1970s, almost 0.5 point over the 1981-86 period, and over 2.5 points since 1986. It should be noted, of course, that the deep recession at the end of the sample period – which hit the manufacturing sector earlier and harder than other industries – was a major contributing factor to the recent decline in the output share of this sector.

As dramatic as the general fall in the manufacturing sector is the rise in the service sector. In its 1992 study, the OECD found that the service sector in all seven countries studied had expanded, led mainly by the financial services group (consisting of finance, insurance, and real estate, and business services). This was and remains true for Canada, as six of the top eleven industries in terms of output shares were service-based in the 1986-91 subperiod. Overall, service-based industries saw their relative share of gross output rise by about five percentage points in the 1980s.

Finally, primary industries and construction seem to have neither lost nor gained output share in any substantive way. Both sectors seem to have at least halted the contraction they were experiencing over the 1971-86 period.

Change at the Industry Level

Underlying these well-known shifts in sectoral profile are developments at the individual industry level. The pattern described above is a familiar one in the industrialized world, but it does not reveal much about the dynamic nature of the changes that are shaping the economy at the industry level.

High-Growth Industries

Looking at the Canadian industrial picture at the 33-industry level – a classification that corresponds to the aggregation scheme used in OECD (1992) – rather than the four broad groupings used above enables us to identify the growth engines in the Canadian economy – namely, those industries whose growth rates are consistently above average (Table 2-4).

Of the thirteen leading growth industries in 1986-91, eight appear among those which led in the two preceding subperiods. Thus these eight industries – computers and office equipment; communication equipment and semiconductors; communication services; real estate and business services; community, social, and personal services; pharmaceuticals; electricity, gas, and water; and finance and insurance – can be seen as Canada's growth engines. Four other industries appear in all three groupings: aircraft manufacturing (or aerospace); mining; wholesale and retail trade; and non-ferrous metals. Only one industry – surprisingly, shipbuilding and repair – appears for the first time in the most recent high-growth grouping.

Table 2-4
Industries with Above-Average Growth Rates of Gross Output, Ranked by Output Share, 1971-91

1971-81	1981-86	1986-91
Computers & Office Equipment	Computers & Office Equipment	Computers & Office Equipment
Communication Services	Motor Vehicles & Parts	Communication Equipment & Components
Real Estate & Business Services	Communication Equipment & Semiconductors	Aircraft Manufacturing
Aircraft Manufacturing	Real Estate & Business Services	Communication Services
Communication Equipment & Semiconductors	Pharmaceutical Products	Real Estate & Business Services
Electricity, Gas & Water	Rubber & Plastics	Shipbuilding & Repair
Finance & Insurance	Finance & Insurance	Community, Social & Personal Services
Community, Social & Personal Services	Communication Services	Pharmaceutical Products
Rubber & Plastics	Wholesale & Retail Trade	Electricity, Gas & Water
Chemical Products	Wood & Furniture	Mining
Hotels & Restaurants	Community, Social & Personal Services	Finance & Insurance
Non-Electrical Machinery & Equipment	Electricity, Gas & Water	Wholesale & Retail Trade
Pharmaceutical Products	Scientific & Photographic Equipment	Non-Ferrous Metals
	Non-Ferrous Metals	
	Mining	
	Transportation & Storage	
	Chemical Products	
	Paper Products & Printing	
Average Annual Gross Output Growth Rate: 4.13%	Average Annual Gross Output Growth Rate: 2.43%	Average Annual Gross Output Growth Rate: 1.97%

In terms of the types of industries dominating the top growth rankings, there is a fairly even split between manufacturing and services in the period 1986-91, with the top three being manufacturing-based.

Most individual industries comprising the service sector – including finance and insurance; communication services; and community, social, and personal services – are ranked among the top ten in all three subperiods; real estate and business services are ranked among the top five.

Low-Growth Industries

Tables 2-5 and 2-6 list those industries which had below-average and negative growth rates, respectively.

As with the leading growth industries, those industries most recently experiencing below-average growth tend to have been in decline in previous periods as well. Interestingly, they are almost all manufacturing-based.

Table 2-5
Industries with Below-Average Growth Rates of Gross Output, Ranked by Output Share, 1971-91

1971-81	1981-86	1986-91
Wholesale & Retail Trade	Agriculture, Forestry & Fishing	Construction
Construction	Non-Metallic Mineral Products	Transportation & Storage
Transportation & Storage	Other Manufacturing	Hotel & Restaurants
Petroleum Refining & Products	Textile, Footwear & Leather	Scientific & Photographic Equipment
Scientific & Photographic Equipment	Food, Beverages & Tobacco	Agriculture, Forestry & Fishing
Shipbuilding & Repair	Fabricated Metal Products	Motor Vehicles & Parts
Wood Products & Furniture	Hotels & Restaurants	Petroleum Refining & Products
Paper Products & Printing		Rubber & Plastics
Other Manufacturing		Food, Beverages & Tobacco
Electrical Equipment & Appliances		
Fabricated Metal Products		
Iron & Steel		
Textile, Footwear & Leather		
Food, Beverages & Tobacco		
Agriculture, Forestry & Fishing		
Motor Vehicle & Parts		
Non-Metallic Mineral Products		
Mining		
Non-Ferrous Metals		
Average Annual Gross Output Growth Rate: 4.13%	Average Annual Gross Output Growth Rate: 2.43%	Average Annual Gross Output Growth Rate: 1.97%

Table 2-6
Industries with Negative Growth Rates of Gross Output, Ranked by Output Share, 1971-91

1971-81	1981-86	1986-91
Transportation Equipment	Construction	Paper Products & Printing
	Electrical Equipment & Appliances	Chemical Products
	Non-Electrical Machinery & Equipment	Other Manufacturing
	Iron & Steel	Iron & Steel
	Other Transportation Equipment	Wood Products & Furniture
	Aircraft Manufacturing	Electrical Equipment & Appliances
	Petroleum Refining & Products	Non-Electrical Machinery & Equipment
	Shipbuilding & Repair	Other Transportation Equipment
		Fabricated Metal Products
		Non-Metallic Mineral Products
		Textiles, Footwear & Leather

The tables show that most of the traditional manufacturing industries are undergoing a severe adjustment, many of them with relatively large shares of manufacturing output. Across the three subperiods, the industries in decline are textile, clothing, footwear, and leather; food, beverages, and tobacco; wood, wood products, and furniture; electrical equipment and appliances; iron and steel; other transportation equipment; other manufacturing and heavy industries, such as fabricated metal products; non-metallic mineral products; and petroleum refining and products. In addition to these are other goods-producing sectors, such as agriculture, forestry and fishing, and construction (Table 2-7).

Table 2-7
Declining Industries, Based on Relative Output Share Change, 1971-91

Decline in All Three Subperiods	Decline in Two Subperiods
Agriculture, Forestry & Fishing	Wood, Wood Products & Furniture
Food, Beverages & Tobacco	Paper, Paper Products & Printing
Textiles, Clothing, Footwear & Leather	Non-Electrical Machinery & Equipment
Petroleum Refining & Products	Shipbuilding & Repair
Non-Metallic Mineral Products	Motor Vehicles & Parts
Iron & Steel	Scientific & Photographic Equipment
Fabricated Metal Products	Hotels & Restaurants
Electrical Equipment & Appliances	Transportation & Storage
Other Transportation Equipment	
Other Manufacturing	
Construction	

Table 2-8
Lilien and Dissimilarity Indexes for 50 and 111 Industries, 1971-91[1]

	Lilien Index		Dissimilarity Index	
	50 Industries	111 Industries	50 Industries	111 Industries
1971-81	1.93	2.54	1.65	2.06
1981-86	2.38	3.02	2.05	2.43
1986-91	1.80	2.27	1.57	1.81

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

The Pace of Structural Change

The analysis above shows that the magnitude of change has differed significantly across sectors. A more rigorous analysis is required to assess whether or not shifts in the structural composition of output have accelerated over time.

Several statistics can be employed to measure the pace of structural change. In Table 2-8 we present two measures of structural change in output, also used in OECD (1994). The first indicator, proposed by Lilien (1982), is the weighted standard deviation of annual output growth by sector; the second, called the dissimilarity index, corresponds to half of the sum of absolute changes in output shares by sector, as proposed by Layard *et al.* (1991).[3] Taking averages over each subperiod serves to remove the effects of cyclical fluctuations in sectoral output. Since these measures can be sensitive to the degree of sectoral aggregation, we use two levels of disaggregation (50 and 111 industries).

Both measures suggest that Canada experienced the greatest degree of structural change during the first half of the 1980s. This result supports the findings of the OECD (1992) and the Department of Finance (1992). However, an important part of the rise in the two measures over the 1981-86 subperiod may be due to the particularly deep recession experienced early in the decade. In other words, cyclical factors may have contributed to the relatively high measured degree of structural change over this period.

Both measures indicate that the pace of structural change during the 1986-91 period either decreased or was generally similar to that of the 1970s. This suggests that Canada experienced significant industrial realignments in the early to mid-1980s, as compared to the 1970s and the second half of the 1980s. This result also points to the importance of structural change in shaping the Canadian economic landscape throughout the period studied here; structural change is apparently no more or less pronounced today than it was in the early 1970s.

Summary

- Structural change is evident at the aggregate level.

- The traditional sectors – primary resources, manufacturing and construction – are losing a great deal of their relative importance in the economy, while the service sector is gaining.
  - Manufacturing has been losing ground in gross industrial output since the 1970s.
  - Services continue to capture output share. The share losses of manufacturing are more than accounted for by services.
  - Declines in the primary industries and construction seem to have halted, at least over the period 1986-91.
- The engines of growth in the Canadian economy have led the way throughout the sample period. There is surprisingly little movement among the growth leaders over time.
- Contrary to a widespread view, the speed of change in the economy does not appear to be accelerating. The pace of structural change may have quickened during the early 1980s, but it has certainly not increased – and may even have decreased – in the late 1980s and early 1990s.

3. THE DIRECTION OF CHANGE

There is an increasingly widespread view among economists and policymakers that in the new global economy, innovation in the uses of people (skills), capital (technology), and ideas (knowledge) is the key to competitive advantage and long-term economic growth. It has been argued that the industries that traditionally led the North American economy have given way to industries whose success is based on knowledge and innovation rather than larger-scale manufacturing muscle (Drucker, 1993; Beck, 1992). In this "new economy," knowledge-based change has created an economic environment in which science and technology play a critical role in generating economic growth (Industry Canada, 1994).[4]

Beck (1992) has pointed to four industrial clusters that provide growth in this new economy: computers & semiconductors; instrumentation; health & medical products; and communications & telecommunications. These industries are highly dependent on knowledge and innovation. The clustering of the computer, communications and semiconductors, communication services, and aerospace industries among the top ten growth industries in the majority of countries has also been noted in OECD (1992).

A more recent OECD study (1996) defines the knowledge-based economy: "The term 'knowledge-based economy' results from a fuller recognition of the role of knowledge and technology in economic growth. Although knowledge has always been a central component in economic development, the fact that the economy is strongly dependent on the production, distribution and use of knowledge is now being emphasized."

In the remainder of the paper we study the "new economy" hypothesis in detail. We look at innovativeness through the knowledge, technology, and skill intensity of output.

A Shift Towards Knowledge-Intensive Industries?

Previous research has revealed a shift towards knowledge- and technology-intensive industries in the structure of the Canadian economy (OECD, 1994). The decline in the price of new technologies has led to an increase in the demand for products that are based on these technologies, such as computers and semiconductors. At the same time, the skills required of employees working in these areas have risen greatly.

No standard definition of high-knowledge intensity exists. Most researchers have attempted to classify industries according to their knowledge intensity based on a single characteristic for measuring knowledge (Beck, 1992; Department of Finance, 1992). Beck (1992) calculates a knowledge ratio for U.S. industries by assessing the proportion of professional, engineering, technical, scientific, and senior management staff and assumes Canadian knowledge industries are the same as those in the United States. This definition, however, is more suitable for *knowledge-using* than *knowledge-producing* industries (Lee & Has, 1996).

The Department of Finance (1992) identifies high-knowledge industries by accounting for the employment of so-called high-knowledge workers. The study uses the proportion of total weeks worked in an industry by workers with a university degree as an indicator of knowledge intensity (calculated from Statistics Canada's 1988 Labour Market Activity Survey). Each industry is then ranked by this "knowledge ratio." The knowledge intensity of industries can of course be captured by other means. For example, one could measure the proportion of weeks worked in an industry with other levels of educational attainment, such as a college diploma or a trade certificate. Alternatively, one could use the proportion of an industry's labour force employed in specified high-knowledge occupations.

The Department of Finance methodology places a heavy emphasis on input use. Like other approaches to the definition of knowledge intensity (e.g., Beck, 1992), this approach is open to criticism and refinement; for instance, it may overstate the knowledge intensity of service industries with high proportions of youth employment. Moreover, the delineation between groups is done so as to keep their employment shares roughly equal – at one third each – which seems arbitrary.

A recent study (Lee & Has, 1996) refines previous attempts at measuring industrial knowledge intensity by combining several knowledge indicators based on R&D activity and human capital content. Three indicators of R&D activity are considered: 1) R&D expenditures by industry (an input measure of innovation activity); 2) the proportion of R&D personnel in total employment; and 3) the proportion of professional R&D personnel (R&D personnel with a university-level degree) in total employment. The measurement of human capital content also takes into account three indicators: 1) the ratio of workers with postsecondary education[5] to total employment; 2) the ratio of knowledge workers[6] to total employment; and 3) the ratio of the number of employed scientists and engineers to total employment.[7]

Lee & Has rank industries by each of the six indicators and divide 55 industries into three knowledge groups.[8] The industries are classified on the basis of the following rules:

- An industry is classified as high-knowledge if at least two of its three R&D indicators belong to the top third of all industries *and* at least two of its three human-capital indicators also belong to the top third.
- An industry is defined as low-knowledge if at least two of its three R&D indicators belong to the bottom third of all industries *and* at least two of its three human-capital indicators also belong to the bottom third.

All remaining industries are classified as medium-knowledge industries.

Appendix Tables A-1 and A-2 present R&D indicators and human capital variables by industry, respectively.[9]

Box 1
Knowledge Intensity Groups

High-Knowledge	Medium-Knowledge	Low-Knowledge
Scientific & Professional Equipment	Other Transportation Equipment	Fishing & Trapping
Communication & Other Electronic Equipment	Other Electrical & Electronic Products	Other Manufacturing Products
Aircraft & Parts	Non-Ferrous Primary Metals	Wood
Computer & Related Services	Textiles	Furniture & Fixtures
Business Machines	Communications	Logging & Forestry
Engineering & Scientific Services	Paper & Allied Products	Transportation
Pharmaceutical & Medical Products	Mining	Storage & Warehousing
Electrical Power	Rubber	Agriculture
Other Chemical Products	Plastics	Retail Trade
Machinery	Primary Ferrous Metals	Personal Services
Refined Petroleum & Coal	Non-Metallic Mineral Products	Quarries & Sand Pits
Management Consulting Services	Wholesale Trade	Accommodation, Food & Beverages
Educational Services	Crude Petroleum & Natural Gas	Clothing
Health & Social Services	Fabricated Metal Products	Leather
Pipeline Transportation	Motor Vehicles & Parts	
Other Business Services	Food	
	Beverages	
	Tobacco	
	Finance, Insurance & Real Estate	
	Other Utilities	
	Services Incidental to Mining	
	Other Services	
	Printing & Publishing	
	Construction	
	Amusement & Recreational Services	

Here, we adopt the Lee & Has classification and map a highly disaggregated level of industries (161) into 55 business sector industries, placing them into high-, medium-, and low-knowledge groups (see Box 1).

The high-knowledge industries identified by this classification scheme tend to be among the past decade's fastest growing, such as electronic products, health services, and business services. Medium-knowledge manufacturing industries tend to be large, mature sectors, whose output is mass-produced and often heavily traded (e.g., motor vehicles, transportation

equipment). Few service industries are found in this group. Low-knowledge industries include labour-intensive manufacturing and traditional service industries (e.g., clothing, retail trade).

The Overall Business Sector

The output of high-knowledge industries clearly expanded over the 1970s and 1980s while that of medium-and low-knowledge industries declined (Chart 3-1).

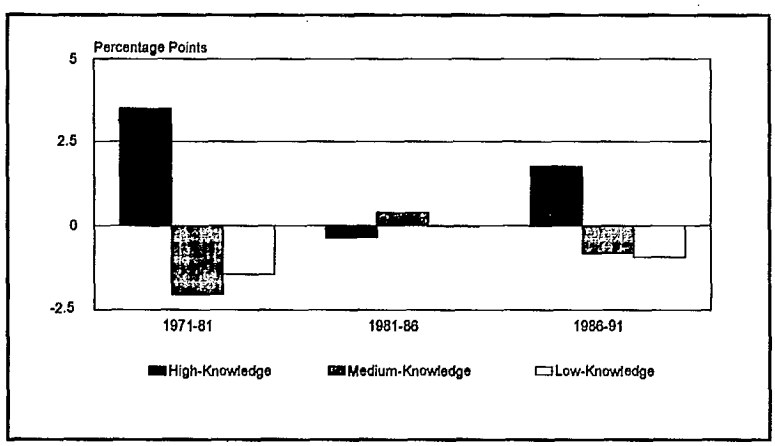
However, the period 1981-86 saw the medium-knowledge group outpace both its low- and high-knowledge counterparts. This resulted largely from the rapid growth of the motor vehicle industry in those years (averaging about 10.7 percent annually). These results are similar to those in OECD (1992), which found that Canadian manufacturing output was led mainly by medium-technology intensive industries over the 1981-86 period.

Somewhat surprisingly, the gain in relative output share recorded by high-knowledge industries was greatest during the 1970s, perhaps because many started from a modest base and grew very rapidly early on.[10]

The average annual growth rates corresponding to the relative shares depicted in Chart 3-1 are shown in Table 3-1. Clearly, the high-knowledge group rebounded strongly in the 1986-91 period, more than doubling the average growth rate of the medium-knowledge sector and of the business sector as a whole.

Despite the superior output performance of the high-knowledge industries, the majority of the Canadian business sector is still comprised of low- and medium-knowledge industries (Chart 3-2).

Chart 3-1
Change in Relative Output Shares, by Level of Knowledge Intensity, Overall Business Sector, 1971-91[1]



1 Percentage points based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 3-1
Industrial Output Growth, by Level of Knowledge Intensity, 1971-91[1]

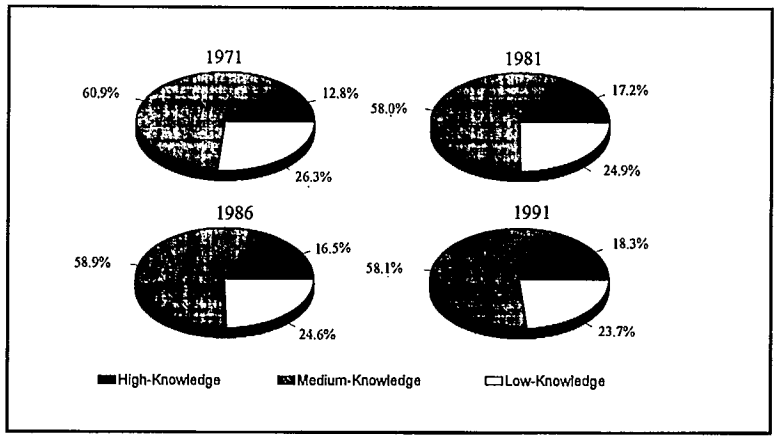
Level of Knowledge Intensity	1971-81	1981-86	1986-91
High	6.68	1.99	4.08
Medium	3.78	2.57	1.68
Low	3.54	2.41	1.18
Overall Business Sector	4.13	2.43	1.97

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

While the relative importance of the output of high-knowledge industries has increased over the past 20 years, not all of these industries have experienced rapid growth. Similarly, not all industries within the medium- and low-knowledge groups have experienced weak growth. Industries such as fishing and trapping, and personal services – both low-knowledge industries – recorded above-average output growth over the period 1986-91 (Table 3-2). However, seven of the top ten fastest growing industries were knowledge-intensive.

Finally, we estimate the pace of structural change, using this knowledge-intensity aggregation scheme. The evidence in Table 3-3 on the pace of structural change in the knowledge economy (based on a 55-industry aggregation scheme) confirms our previous findings, reported in Table 2-8, that the pace of structural change did not accelerate during the period 1986-91 – and, indeed, may have decreased.

Chart 3-2
Industrial Output Shares, by Level of Knowledge Intensity, Overall Business Sector, 1971-91[1]



1 Percentages based on data expressed in 1971 prices (1971), 1981 prices (1981), and 1986 prices (1986 and 1991).

Table 3-2
Output Growth in the Top 20 Business Sector Industries, by Level of Knowledge Intensity, 1986-91[1]

Industries	Knowledge Level	1986-91
Office, Store & Business Machines	High	21.76
Communication & Other Electrical Equipment	High	13.54
Aircraft & Aircraft Parts	High	7.24
Communications	Medium	7.09
Pipeline Transportation	High	6.55
Other Business Services	High	6.09
Personal Services	Low	6.02
Health & Social Services	High	4.07
Pharmaceutical & Medical Products	High	3.79
Fishing & Trapping	Low	3.61
Crude Petroleum & Natural Gas	Medium	3.58
Wholesale Trade	Medium	3.52
Educational Services	High	3.44
Non-Metal Mines	Medium	3.14
Amusement & Recreational Services	Medium	2.90
Electrical Power	High	2.84
Finance, Insurance & Real Estate	Medium	2.84
Mining (Metals)	Medium	2.62
Plastics	Medium	2.27
Non-Ferrous Primary Metals	Medium	2.27

1 Compound average annual growth rates, based on a 55-industry aggregation.

Table 3-3
Lilien and Dissimilarity Indexes for the Knowledge Economy, Overall Business Sector, 1971-91[1]

	Lilien Index	Dissimilarity Index
1971-81	2.21	1.79
1981-86	2.74	2.24
1986-91	2.05	1.71

1 Average annual percentages, based on a 55-industry disaggregation scheme and on 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

The Manufacturing Sector

In this section, we focus on structural change in the manufacturing sector only. Previous sections have documented the relatively low – and declining – share of manufacturing gross output.

Manufacturing nonetheless retains its overall importance as it plays a leading role in innovation and strongly influences other sectors of the economy, especially as a supplier of capital equipment.

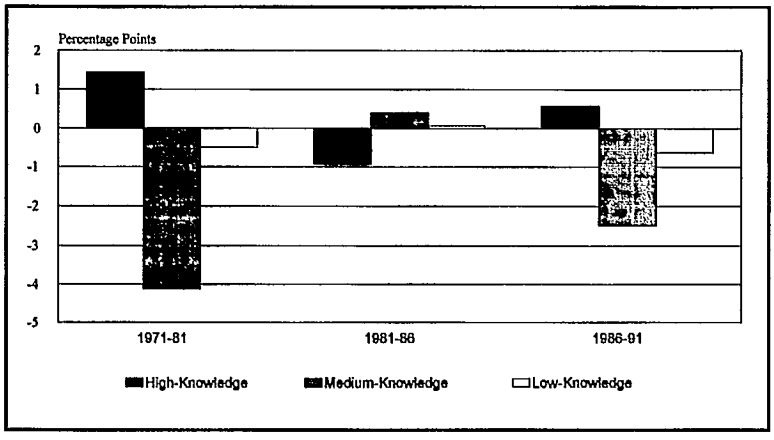
The overall manufacturing sector in Canada has been declining over the long term, consistently losing output share to the service sector since the 1970s. However, this decline has not been uniform in all manufacturing industries. Indeed, a clear shift can be discerned in the composition of manufacturing output towards knowledge-intensive industries.

While knowledge intensity is one indicator of innovativeness, some researchers have used other classifications schemes based on characteristics such as technology intensity (as measured by R&D expenditures), wage levels, sector orientation, and skill intensity (OECD, 1994; Sakurai, 1995; Papaconstantinou, 1995; and Baldwin & Raffiquzzaman, 1994). These characteristics obviously have a high degree of correlation with knowledge intensity. The classification schemes based on them are described in Appendix B.

Knowledge Intensity

Chart 3-3 shows that, in the most recent period, only high-knowledge industries, among the three manufacturing groups, registered a gain in output share relative to the overall business sector. This advance was led by industries such as office, store, and business machines; electronic equipment; aircraft and aircraft parts; and pharmaceutical and medical products (Table 3-4). In contrast, the output shares of low- and medium-knowledge manufacturing industries fell.

Chart 3-3
Change in Relative Output Shares in Manufacturing, by Level of Knowledge Intensity, 1971-91[1]



1 Percentage points based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

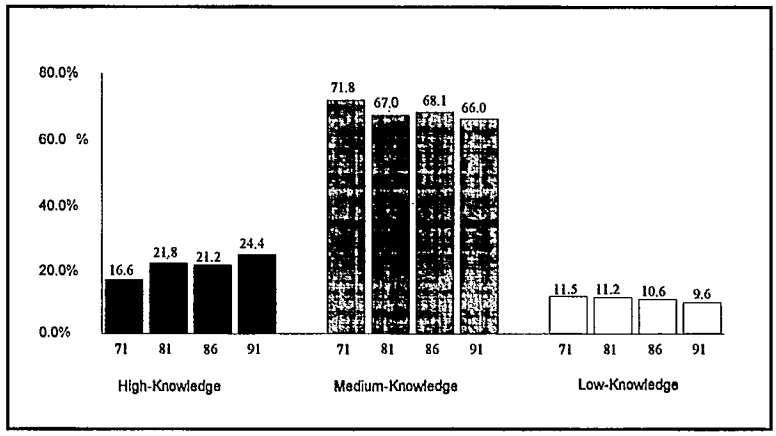
Table 3-4
Output Growth in the Manufacturing Sector, by Level of Knowledge Intensity, 1986-91[1]

Industries	1986-91
High-Knowledge	
Office, Store & Business Machines	21.76
Communication & Other Electronic Equipment	13.54
Aircraft & Aircraft Parts	7.24
Pharmaceutical & Medical Products	3.79
Scientific & Photographic Equipment	0.96
Refined Petroleum & Coal Products	0.85
Chemicals & Chemical Products	-0.34
Machinery	-1.35
All High-Knowledge Industries	3.36
Medium-Knowledge	
Primary Metals (Non-Ferrous)	2.27
Plastic Products	2.27
Other Transportation Equipment	1.34
Motor Vehicles & Parts	0.84
Food	0.40
Paper & Allied Products	-0.13
Printing & Publishing	-0.23
Primary Metals (Ferrous)	-0.40
Fabricated Metal Products	-1.11
Beverages	-1.65
Rubber Products	-2.24
Other Electrical & Electronic Products	-2.35
Textiles	-2.56
Non-Metallic Mineral Products	-2.82
Tobacco Products	-3.21
All Medium-Knowledge Industries	-0.05
Low-Knowledge	
Wood	0.04
Other Manufacturing Products	-0.42
Clothing	-2.15
Furniture & Fixtures	-3.55
Leather	-9.26
All Low-Knowledge Industries	-1.39

1 Average annual percentages, based on data expressed in 1986 prices.

Given the overall contraction of the manufacturing sector's output, it seems that only high-knowledge industries have been able to maintain or increase their output shares over the second half of the past decade – a trend that was also evident in the 1970s but not during the early 1980s.

Chart 3-4
Output Shares in Manufacturing, by Level of Knowledge Intensity, 1971-91[1]



1 Percentages based on data expressed in 1971 prices (1971 and 1981), and 1986 prices (1986 and 1991).

Manufacturing remains dominated by medium-knowledge industries (Chart 3-4). While the composition of output appears to be shifting towards knowledge-intensive industries, medium-knowledge industries still made up two thirds of the manufacturing sector's total output in 1991.

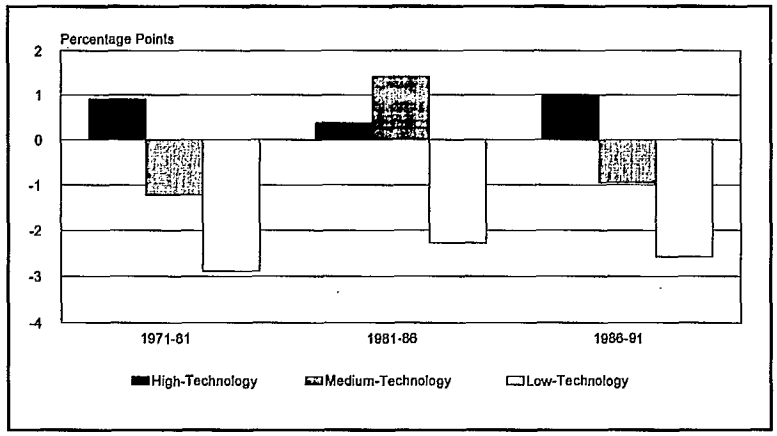
Technology Intensity

High-technology industries are usually identified as those which display a strong R&D effort, relatively high employment of scientists and engineers, or both (Tyson, 1992; Krugman, 1991; and OECD, 1994). By making large investments in knowledge creation, these industries play a key role in the long-run performance of the economy, as they produce substantial spill-over benefits; provide high-skill, high-wage employment; generate higher returns to capital and labour than are available elsewhere in the economy (Katz & Summers, 1989); and attract high-quality foreign direct investment.

In examining the technological intensity of Canadian manufacturing, the OECD (1992) study concluded (p. 29) that "although included in the moderate change tier, Canada had a pattern of output growth sequenced differently from that in other countries. From 1981 to 1986, medium-technology manufacturing had the largest gains ... high-technology also gained, but these increases were relatively small."

Are these conclusions still valid? To answer that question, we use spending on R&D as a proportion of gross output, as a measure of technological intensity – the standard OECD classification scheme (OECD, 1987)[11] – and we group 85 manufacturing industries into 22 high-, medium-, and low-technology categories.

Chart 3-5
Change in Relative Output Shares in Manufacturing, by Level of Technology Intensity, 1971-91[1]



1 Percentage points based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Chart 3-5 illustrates the change in the relative shares of high-, medium-, and low-technology manufacturing industries. The high-technology sector clearly enjoyed output share gains throughout the sample period, although the magnitude of these gains was less pronounced between 1981 and 1986. During this period, medium-technology manufacturing, again led by the automobile industry, had the largest gains (1.4 percentage point). High-technology manufacturing was led by such industries as computers and office equipment, communication equipment and semiconductors, and pharmaceutical and medical products.

Table 3-5 reports the consistently above-average growth rates of high-technology manufacturing throughout the sample period relative to both the manufacturing sector and the overall business sector. While the high-technology sector has clearly gained output share over the 20-year period, both medium- and especially low-technology industries had fallen behind by the end of the 1980s.

Table 3-5
Output Growth in the Manufacturing Sector, by Level of Technology Intensity, 1971-91[1]

Level of Technology Intensity	1971-81	1981-86	1986-91
High	6.68	4.80	7.60
Medium	3.07	4.80	0.40
Low	2.87	0.50	-0.50
All Manufacturing Industries	3.29	2.17	0.58

1 Average annual percentages, based on a disaggregation into 8 high-technology, 25 medium-technology and 52 low-technology manufacturing industries and on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 3-6
Composition of Gross Output in the Manufacturing Sector, by Level of Technology Intensity, 1971-91[1]

	1971-81		1981-86		1986-91	
Level of Technology Intensity	**1971**	**1981**	**1981**	**1986**	**1986**	**1991**
High	8.09	11.18	7.88	8.93	8.41	11.78
Medium	30.53	29.90	29.31	33.31	34.03	33.78
Low	61.38	58.92	62.81	57.76	57.55	54.44
Total	100.00	100.00	100.00	100.00	100.00	100.00

1 Percentages based on a disaggregation into 8 high-technology, 25 medium-technology, and 52 low-technology industries and on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Again, it must be borne in mind that despite shrinking relative output shares and growth rates, medium- and especially low-technology manufacturing still account for the bulk of total industrial output in Canada, as the absolute shares of gross output reported in Table 3-6 make clear.

An important point to note, then, is that the growth in output share in the high-technology industries was more dramatic during the 1986-91 period: high-technology production in overall manufactured output increased by more than 40 percent. If this is a reflection of any long-term trend, it might be safe to say that Canada's manufacturing production is experiencing a long-run shift towards high-technology sectors. One explanation for relatively strong output gains in high-technology manufactured products during the 1980s and early 1990s might be the relatively high income elasticity of demand for these products in an increasingly integrated North American economy.

By international standards, the output performance of Canadian high-technology manufacturing industries has been inferior. In Canada, the share of their output accounted for about 12 percent of total real output in 1991 – a figure markedly lower than in some of the other major OECD economies. Estimates show that in 1990 high-technology goods accounted for about 30 percent of manufactured output in the United States, about 20 percent in Europe, and about 35 percent in Japan (Tyson, 1992).

Skill Intensity

The growing importance of high-technology, high-knowledge industries has implications for the skill composition of employment in the Canadian economy. The manner in which technological sophistication affects the demand for particular types of skills is of great importance to the debate regarding Canada's upward-trending unemployment rate. Here, we examine the changing output structure of manufacturing industries in terms of the skill composition of their workforce.

Table 3-7
Composition of Gross Output in the Manufacturing Sector, by Level of Skill Intensity, 1971-91[1]

Level of Skill Intensity	1971-81	1981-86	1986-91
Skilled	50.13	56.38	52.22
Unskilled	49.87	43.62	47.78
Total	100.00	100.00	100.00

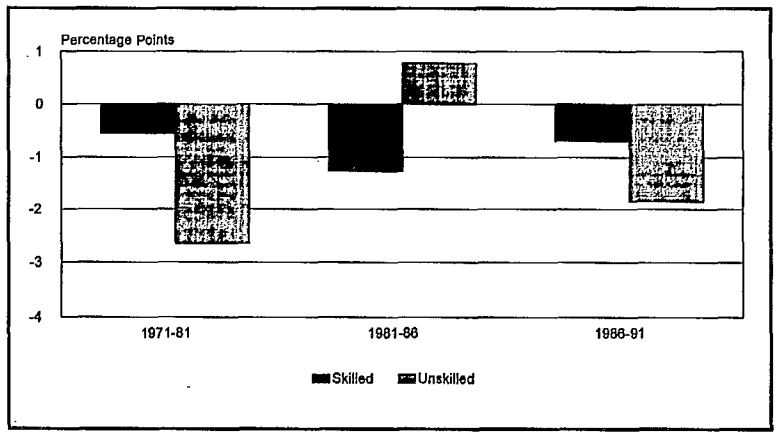
1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

To that end, manufacturing industries are divided into skilled and unskilled groups (see Appendix B), following the OECD (1994) classification scheme, which groups industries on the basis of the proportion of production workers (who are assumed to be unskilled).

In terms of absolute shares of manufacturing output, industries with higher skill requirements have consistently accounted for a larger proportion of total manufacturing output than their more moderately skilled counterparts (Table 3-7).

The general malaise of the manufacturing sector means that both of these groups lost relative shares of total output between 1986 and 1991, although unskilled industries did so at twice the rate experienced by skilled industries. In the period 1981-86, however, skilled industries lost over 1.2 percentage point of their output while unskilled industries actually saw their shares rise, largely as a result of the strong performance of the motor vehicle industry (Chart 3-6).

Chart 3-6
Change in Relative Output Shares in Manufacturing, by Level of Skill Intensity, 1971-91[1]



1 Percentage points based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Among skilled manufacturing industries, computers and office equipment, pharmaceuticals, and communication equipment all enjoyed very strong growth rates over the course of each subperiod. Thanks to government expenditures, shipbuilding and repair were one of the few highlights among the unskilled industries by the end of the period. Eight of twelve unskilled industries shrank over the period 1986-91, as compared to three out of ten skilled industries.[12]

Wage Levels

As with skill requirements, the growing importance of the high-technology, high-knowledge intensive sectors has implications for the types of wages paid in the Canadian economy. The manner in which technological sophistication affects not only the demand for particular types of skills but also the wages that are paid for those skills is of interest to policymakers. In a recent study, Katz & Summers (1989) argue that inter-industry wage differentials provide a strong rationale for trade and industrial policies.[13] The underlying argument is that policies that encourage employment in high-wage sectors are likely to shift labour from low- to high-productivity uses, thereby increasing total output.

We examine structural change in manufacturing industries disaggregated into high-, medium-, and low-wage groups, following the OECD classification scheme, based on average labour compensation across nine OECD countries (see Appendix B).

Within manufacturing, the gross output share of high-wage industries has consistently increased over the sample period. These industries had caught up to and passed their low-wage counterparts by 1986, though they still fell short of medium-wage industries as a proportion of manufacturing output. The medium-wage group's output share has remained fairly constant throughout the sample period, while the low-wage group has suffered steady declines (Table 3-8).

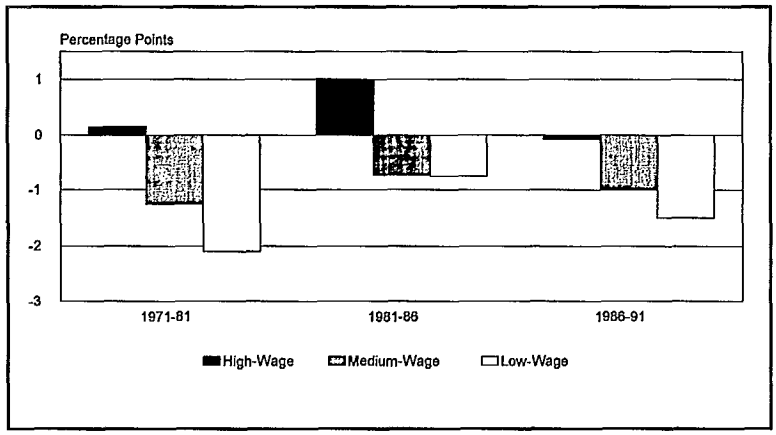
The general decline of the manufacturing sector within the economy as a whole means that all three wage groups experienced falling relative shares of total output at the end of the sample period. However, high-wage industries had the smallest declines, while low-wage

Table 3-8
Composition of Gross Output in the Manufacturing Sector, by Wage Level, 1971-91[1]

	1971-81		1981-86		1986-91	
Wage Level	**1971**	**1981**	**1981**	**1986**	**1986**	**1991**
High	22.97	25.32	28.98	31.90	30.53	32.51
Medium	39.71	39.76	38.55	37.16	37.82	37.79
Low	37.32	34.92	32.47	30.94	31.64	29.71
Total	100.00	100.00	100.00	100.00	100.00	100.00

1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Chart 3-7
Change in Relative Output Shares in Manufacturing, by Wage Level, 1971-91[1]



1 Percentage points based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 3-9
Output Growth in the Manufacturing Sector, by Wage Level, 1971-91[1]

Wage Level	1971-81	1981-86	1986-91
High	4.30	4.15	1.84
Medium	3.30	1.43	0.56
Low	2.60	1.19	-0.68
All Manufacturing Industries	3.29	2.17	0.58

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

industries lost almost 1.5 percentage point between 1986 and 1991 (Chart 3-7). In the two previous subperiods, the high-wage sector alone enjoyed share increases relative to the business sector as a whole. Table 3-9 reports consistently above-average growth rates relative to the manufacturing sector as a whole.

Sectoral Orientation

The next step in our study is an investigation of structural change in five groups of manufacturing industries based on their sector orientation – natural resource-based, labour-intensive, product-differentiated, scale-based, and science-based (see Appendix B). The taxonomy for this grouping is from the OECD (1987, 1994) and from Baldwin & Rafiquzzaman (1994).[14]

Natural resource-based industries are characterized as being primarily processors of raw materials, with a high ratio of sales to domestic value-added. The labour-intensive group is

composed of industries with low capital/labour ratios, low wage rates, and relatively small plants. The product-differentiated group is made up of industries where advertising/sales ratios, R&D expenditures, and the number of goods produced are large. Scale-based manufacturers are those with high capital/labour ratios, relatively high wage rates, and larger plants. Finally, the science-based group is generally composed of the high-tech industries, where R&D expenditure is high, a large proportion of the workforce is employed in scientific or professional occupations, and there is a fairly high degree of foreign ownership (Baldwin & Rafiquzzaman, 1994)

The scale-intensive and natural resource-based manufacturing groups had respectively the largest and second largest share of output throughout the sample period (Table 3-10); together, these two groups accounted for almost three quarters of all manufacturing output and over 10 percent of the economy's total output over the period 1986-91. Science-based industries, while continuing to expand, accounted for the smallest share of manufacturing output.

Chart 3-8 presents the changes in each of the groupings' relative share of total output for each subperiod. The natural resource- and labour-intensive sectors seem to be in long-term decline, with shrinking shares of output in each subperiod. Scale-intensive industries also seem to be experiencing readjustment: despite a 1.3-point gain in the early 1980s (due mainly to the strong output performance of the automobile industry), this group lost more total output share than any other over the second half of the decade. Only shipbuilding and repair experienced above-average growth among scale-intensive manufacturers over this period.

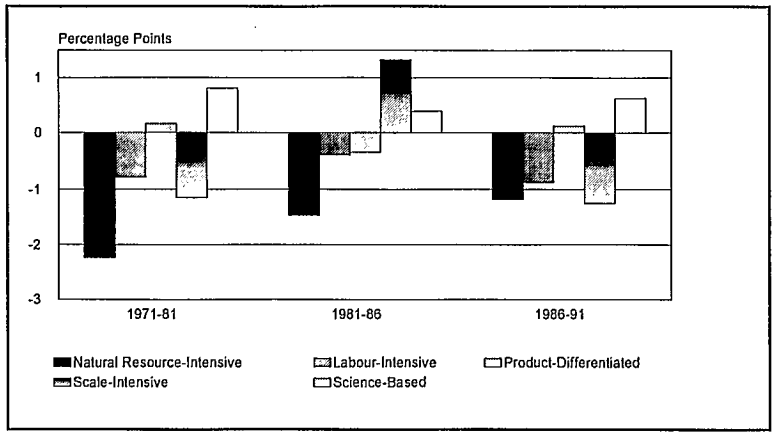
Product-differentiated industries enjoyed slight share gains over the period 1986-91, almost wholly as a result of the extremely strong export performance of the communication equipment industry. In fact, in this group communication equipment is the only industry to post positive growth rates during the 1980s. The science-based industries, which account for less manufacturing output than any other grouping, are the only group to consistently gain share throughout the sample period.

Table 3-10
Composition of Gross Output in the Manufacturing Sector, by Sector Orientation, 1971-91[1]

	1971-81		1981-86		1986-91	
Orientation	**1971**	**1981**	**1981**	**1986**	**1986**	**1991**
Natural Resource-Intensive	36.74	33.92	39.52	36.27	34.65	33.84
Labour-Intensive	15.76	15.02	13.34	12.50	12.56	10.99
Product-Differentiated	9.24	10.45	8.89	8.12	8.47	9.42
Scale-Intensive	35.19	35.13	34.73	38.54	40.40	39.80
Science-Based	3.08	5.48	3.53	4.56	3.93	5.95
Total	100.00	100.00	100.00	100.00	100.00	100.00

1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Chart 3-8
Change in Relative Output Shares in Manufacturing, by Sector Orientation, 1971-91[1]



1 Percentage points based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 3-11
Lilien and Dissimilarity Indexes for the Manufacturing Sector, 1971-91[1]

	Lilien Index		Dissimilarity Index	
	21 Industries	85 Industries	21 Industries	85 Industries
1971-81	1.97	3.23	1.77	2.73
1981-86	2.69	3.97	2.57	3.38
1986-91	2.02	3.09	1.90	2.58

1 Average annual percentages based on 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

The Pace of Change

Did the pace of structural change in the manufacturing sector accelerate during the 1980s? To answer that question, we again calculate two measures of structural change – the Lilien index and the dissimilarity index – in manufacturing output.

The analysis shows that the pace of structural change in the manufacturing sector was similar to that observed for the overall business sector (Table 3-11). Again, both measures indicate that the manufacturing sector experienced the greatest degree of structural change during the first half of the 1980s and that the pace of change did not quicken in the late 1980s and early 1990s.[15]

The Service Sector

As shown earlier, the growth of the Canadian service sector has been unmatched by that of any other broad sector during any of the periods examined here. Services as a whole gained over

Table 3-12
Output Growth in the Service Sector, by Level of Knowledge Intensity, 1971-91[1]

Level of Knowledge Intensity	1971-81	1981-86	1986-91
High	7.25	4.09	4.76
Medium	6.39	4.18	3.44
Low	4.06	2.48	1.93
All Service Industries	5.59	3.49	3.16

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

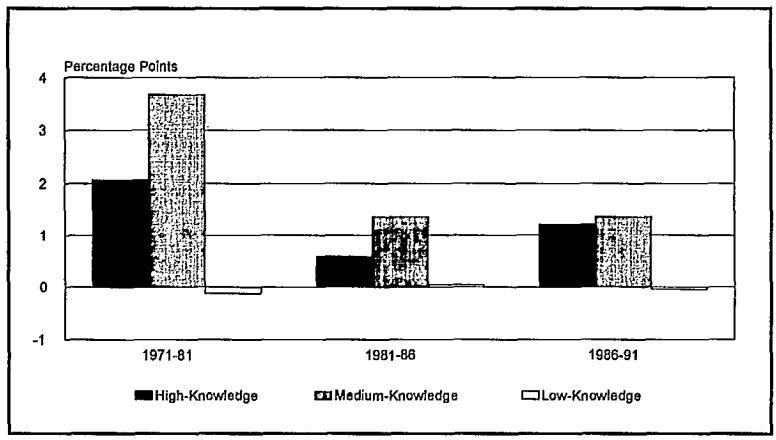
4.7 percentage points in gross output over the last decade, largely at the expense of manufacturing (see Table 2-3). However, although services accounted for about 60 percent of business sector GDP and were the main source of job gains during the 1980s, they have not been studied to the same extent as manufacturing. In this section, we focus on output shifts within the service sector and ask whether service industries in Canada have moved up the knowledge intensity scale.

Table 3-13
Output Growth of Service Industries, by Level of Knowledge Intensity, 1971-91[1]

	1971-81	1981-86	1986-91
High-Knowledge			
Pipeline Transport	2.78	2.33	6.55
Business Services	9.20	5.15	6.09
Health & Social Services	5.80	3.42	4.07
Educational Services	4.03	4.86	3.44
Electrical Power Systems	6.53	3.27	2.84
All High-Knowledge Services	7.25	4.09	4.76
Medium-Knowledge			
Communications	10.28	4.04	7.09
Wholesale Trade	4.76	4.72	3.52
Amusement & Recreation	6.73	6.59	2.90
Finance, Real Estate & Insurance	5.98	4.40	2.84
Gas Distribution Systems	4.05	1.23	1.88
Services Incidental to Mining	12.71	-3.53	-1.14
All Medium-Knowledge Services	6.39	4.18	3.44
Low-Knowledge			
Personal Services	6.42	2.71	6.02
Retail Trade	3.37	3.30	1.63
Accommodation & Food Services	4.69	0.31	1.30
Transportation	3.98	2.62	1.23
Other Services	3.53	4.23	0.91
Storage & Warehousing	2.03	1.35	-0.11
All Low-Knowledge Services	4.06	2.48	1.93

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Chart 3-9
Change in Relative Output Shares in Services, by Level of Knowledge Intensity, 1971-91[1]



1 Percentage points based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Like manufacturing, the service sector is a multifaceted group, made up of a wide range of diverse industries. Accordingly, as was done for the manufacturing sector, we differentiate services on the basis of their knowledge intensity (see Box 1). This is predominantly a *knowledge-using* rather than *knowledge producing* sector.

Table 3-12 shows output growth in service industries grouped by level of knowledge intensity. High-knowledge industries outpaced both the service sector as a whole and the overall business sector. So, too, did medium-knowledge services, which even outpaced their high-knowledge counterparts during the first half of the 1980s, thanks largely to high growth in amusement and recreational services during that period. In the late 1980s, medium-knowledge services were led by communication services (i.e., telecommunications), while business services and pipeline transport boosted the average growth rate of the high-knowledge service group (Table 3-13). Personal services were the one well-performing industry in the low-knowledge service group over the last subperiod.

High- and medium-knowledge services both gained relative output share in each subperiod. Despite stronger growth among high-knowledge services in the late 1980s, however, medium-knowledge industries gained slightly higher relative shares (Chart 3-9). Thus the economy is becoming increasingly dominated by knowledge-intensive service industries.

In absolute terms, the share of high-knowledge service industries grew strongly over the period – from 16 percent in 1971 to over 21 percent by 1991. Medium-knowledge services also saw their absolute shares increase steadily, all at the expense of low-knowledge services (Table 3-14).

Table 3-14
Composition of Gross Output in the Service Industries, by Level of Knowledge Intensity, 1971-91[1]

	1971-81		1981-86		1986-91	
Level of Knowledge Intensity	**1971**	**1981**	**1981**	**1986**	**1986**	**1991**
High	16.0	18.7	18.5	19.1	19.7	21.3
Medium	40.5	43.7	41.1	42.5	43.2	43.8
Low	43.5	37.6	40.4	38.5	37.1	35.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Summary

Overall Business Sector

- Industrial structural change is evident when knowledge intensity is used as an indicator. The Canadian business sector appears to be moving up the knowledge intensity scale – a shift that has been taking place since the early 1970s.
- Despite this superior performance, the Canadian business sector is still largely comprised of medium- and low-knowledge industries.

Manufacturing Sector

- In manufacturing, high-knowledge industries have generally been the only group able to maintain and even increase their relative share of gross output. Medium- and low-knowledge manufacturers have seen their output shares eroded during the second half of the 1980s.
- Structural change in the manufacturing sector is also evident when industries are grouped on the basis of technological sophistication. High-technology manufacturers have consistently outpaced not only the manufacturing sector as a whole but also the overall business sector. Medium- and low-technology manufacturers were unable to maintain their relative output shares in the latter part of the period under review.
- Manufacturing industries were also differentiated by wage rates and skill levels. Those industries which employed higher-skilled labour fared better in the late 1980s than those which tended to used unskilled labour. As well, higher-paying manufacturing industries clearly experienced above-average growth, in contrast to their low- and medium-wage counterparts.
- An examination of the sectoral orientation of manufacturing industries shows that science-based industries consistently enjoyed above-average growth rates, as did product-differentiated industries in the latter part of the sample period. The other groups all suffered declining relative output shares.

Service Sector

- The service sector has undergone much the same evolution, in terms of knowledge intensity, as has manufacturing: high-knowledge service industries outpaced the service sector as a whole and the overall business sector. So, too, did medium-knowledge services.
- The Canadian business sector is becoming increasingly dominated not just by services (at the expense of manufacturing), but more specifically by knowledge-intensive service industries.

Thus, the "new economy" hypothesis is largely supported by the data reviewed here: there is clear evidence that the structure of manufacturing output in Canada is shifting towards high-knowledge and high-technology industries, and that an increasing proportion of output is accounted for by industries that have higher skill requirements and pay higher wages. The clustering of certain high-technology/high-knowledge industries is also documented by Beck (1992). We do not find this to be a new phenomenon, but one with roots at least as far back as the early 1970s. The growth experienced by these "new economy" industries over time has meant that they now play a role of unprecedented importance in the generation of wealth in the Canadian economy.

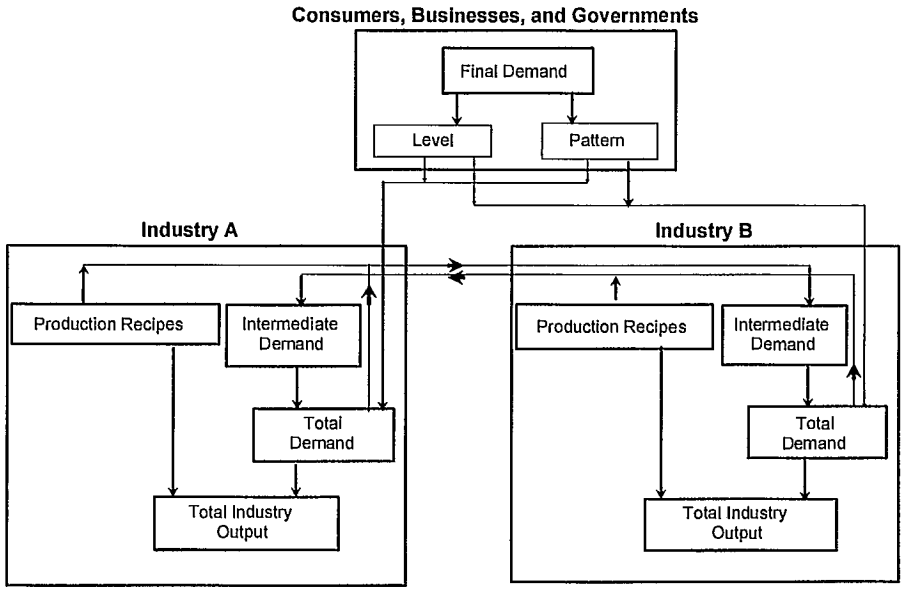
4. SOURCES OF OUTPUT GROWTH

In this chapter, we identify the factors that have contributed to structural shifts in output growth over our sample period, from 1971 to 1991. Input/output techniques are used to decompose output growth into five factors:

- Changes associated with domestic final demand (DFD): changes in personal consumption, in investment, and in government expenditures;
- Changes associated with exports;
- Changes associated with imports of final goods and intermediate inputs;
- Changes in production techniques (i.e., in input/output coefficients);
- Changes due to other factors, such as market shares and other leakages in the substitution of final demand and intermediate goods.

Input/output techniques are particularly useful because they capture flows of goods and services between different industries and allow the indirect effects of such interlinkages to be captured. The input/output model also makes it possible to calculate the contribution of changing production techniques to output growth. Because these changing techniques imply a change in the composition of intermediate inputs used by an industry, they also represent a change in the production "recipe" for the industry and thus can be loosely interpreted as a change in its technology (see Box 2).

Box 2
Demand, Production Recipes and Output – The Linkages



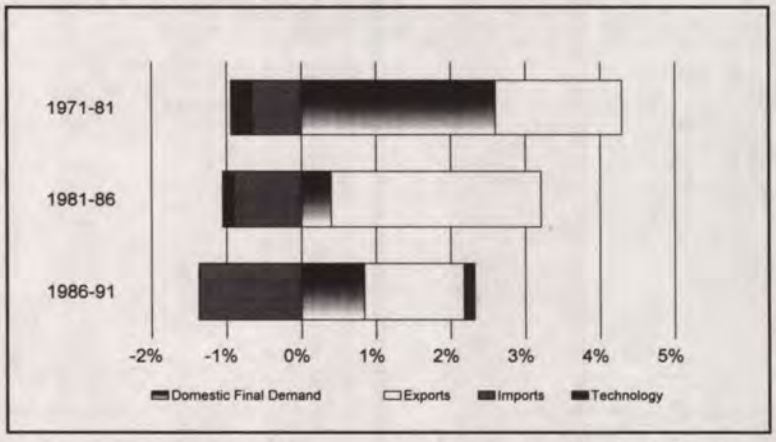
It is important to note that the input/output approach has been criticized on a number of grounds: the absence of any behavioural content, the static nature of the analysis, the assumption of fixed input/output labour coefficients, and the failure to account for the effects of scale economies. In addition, the five factors employed in the decomposition analysis may not be independent of each other; for example, trade and technology may be highly correlated. The detailed output growth decomposition methodology is explained in Appendix D.

The last source of output change – namely, changes in market shares and in other leakages in the substitution of final demand and intermediated goods – warrants further discussion. This term not only measures the effects of market shares – i.e., the fact that some industries may have gained market share at the expense of others – but also groups all the remaining effects that can be captured with the input/output model. These include changes in the share of supply that comes from government production and from inventories, as well as other miscellaneous leakages of intermediate or final goods. The contribution of this factor to output change is negligible, and we do not report it in the decomposition tables.

The Manufacturing Sector

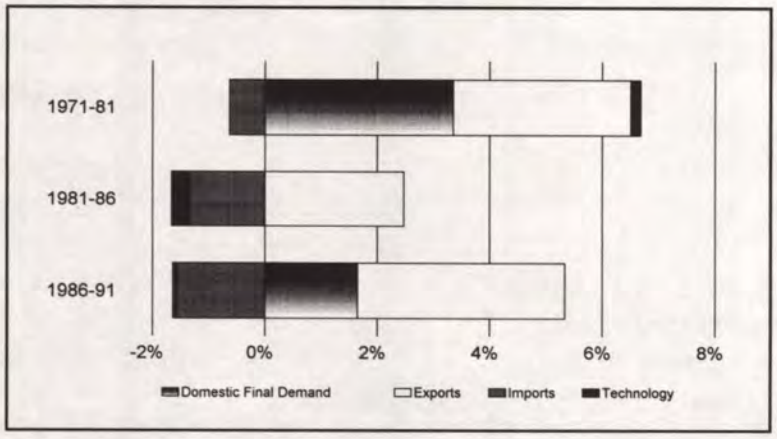
Chart 4-1 shows the decomposition of output growth in the manufacturing sector over our three subperiods – 1971-81, 1981-86, and 1986-91. The chart reveals that trade (exports and imports) rose to prominence in the 1980s, replacing domestic demand as the prime factor of output growth. In the most recent subperiod, changes in production techniques have begun to have a positive effect on output growth, and import penetration is emerging as a major factor in the reduction of output growth in this sector. Relatively recent policy shifts towards freer trade (through the Canada-U.S. Free Trade Agreement and the North American Free Trade Agreement) and the globalization of the marketplace are reflected by the dominant role of trade evident in Chart 4-1.

Chart 4-1
Sources of Output Growth in the Manufacturing Sector, 1971-91[1]



1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Chart 4-2
Sources of Output Growth in High-Knowledge Manufacturing Industries, 1971-91[1]



1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Knowledge Intensity

High-Knowledge Industries

Although the gross output of high-knowledge industries represents a relatively modest part of total manufacturing output (about 25 percent in 1991), these industries have proven to be the engines of sectoral growth throughout the 1970s and 1980s. Not surprisingly, high-knowledge manufacturing industries derived most of their success from their export performance, while domestic demand became a decidedly secondary factor (Chart 4-2). Import penetration also increased, though to a much lesser extent.

Looking at individual industries, we find that output in such areas as office, store, and business machines; aerospace; and communication and other electronic equipment depended heavily on export-led growth (Table 4-1). In these industries, technological changes have also made positive contributions to output growth. In contrast, the increase in output in the pharmaceutical and medical products industry is attributable to domestic final demand.

Medium-Knowledge Industries

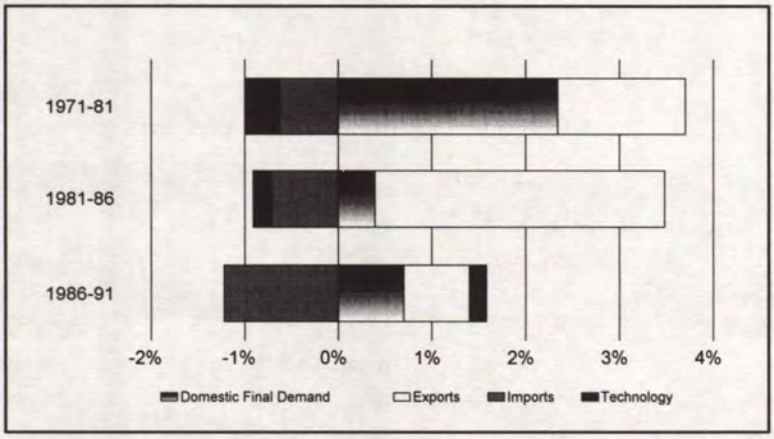
Domestic final demand was by far the most important factor driving output growth in medium-knowledge manufacturing industries during the 1971-81 period, with 11 of the 15 industries being led by this factor. However, exports began to play a much more significant role in the 1981-86 period. During the 1986-91 period, the negative contribution of import penetration was more pronounced, reflecting a lack of competitiveness in these industries (Chart 4-3).

Table 4-1
Sources of Output Growth in High-Knowledge Manufacturing Industries, 1971-91[1]

		Sources of Output Growth			
	Growth Rate	Domestic Final Demand	Exports	Import Penetration	Technical Change
1971-81					
Scientific & Photographic Equipment	3.50	3.91	2.15	-1.86	0.55
Electronic Equipment	7.83	4.43	4.51	-2.39	0.67
Aircraft & Aircraft Parts	8.68	2.43	5.89	1.08	0.22
Office, Store & Business Machines	19.97	9.73	14.59	-7.21	1.49
Pharmaceutical & Medical Products	4.29	4.19	0.64	-0.60	1.05
Chemicals & Chemical Products	5.52	2.76	2.30	-0.03	0.43
Machinery	5.38	2.82	2.43	-0.14	0.21
Refined Petroleum	3.73	2.37	1.06	0.61	-0.57
All High-Knowledge Manufacturing	6.14	3.35	3.15	-0.63	0.18
1981-86					
Scientific & Photographic Equipment	3.04	1.13	2.66	-1.01	-0.27
Electronic Equipment	5.57	0.29	4.21	-0.91	0.95
Aircraft & Aircraft Parts	-2.75	-1.49	0.03	0.68	0.18
Office, Store & Business Machines	24.73	3.28	25.25	-2.44	0.59
Pharmaceutical & Medical Products	4.98	4.06	0.25	-0.28	-0.83
Chemicals & Chemical Products	2.58	0.73	2.47	-1.20	0.39
Machinery	-2.77	-0.67	-0.86	-1.71	-0.37
Refined Petroleum	-3.77	-0.95	1.25	-1.64	-1.18
All High-Knowledge Manufacturing	0.47	-0.01	2.47	-1.33	-0.32
1986-91					
Scientific & Photographic Equipment	0.96	1.67	4.50	-3.60	0.99
Electronic Equipment	13.54	4.50	7.46	-0.58	0.43
Aircraft & Aircraft Parts	7.24	1.03	4.96	-0.12	0.68
Office, Store & Business Machines	21.76	1.72	19.43	-0.98	0.29
Pharmaceutical & Medical Products	3.79	4.06	0.48	-0.66	0.10
Chemicals & Chemical Products	-0.34	1.10	2.54	-3.22	-0.18
Machinery	-1.35	1.66	0.14	-0.80	-0.11
Refined Petroleum	0.85	0.79	2.00	-1.06	-0.62
All High-Knowledge Manufacturing	3.36	1.65	3.68	-1.56	-0.08

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Chart 4-3
Sources of Output Growth in Medium-Knowledge Manufacturing Industries, 1971-91[1]



1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 4-2
Sources of Output Growth in Medium-Knowledge Manufacturing Industries, 1971-91[1]

		Sources of Output Growth			
	Growth Rate	Domestic Final Demand	Exports	Import Penetration	Technical Change
1971-81					
Other Transportation Equipment	0.76	2.09	0.25	-0.73	0.32
Other Electrical & Electronic Products	2.81	4.42	1.28	-2.08	-0.73
Primary Metals (Non-Ferrous)	0.80	1.18	0.82	-0.62	-0.19
Textiles	3.21	3.46	1.18	-0.56	-0.96
Paper & Allied Products	2.51	1.67	1.77	-0.40	-0.28
Rubber Products	3.66	2.87	3.01	-0.91	-0.87
Plastic Products	7.90	3.53	1.56	-0.81	1.18
Primary Metals (Ferrous)	-2.01	-0.91	1.56	0.61	-2.24
Fabricated Metal Products	2.66	3.35	1.51	-0.76	-1.21
Motor Vehicles & Parts	2.03	1.39	2.22	-0.93	-0.12
Food	2.61	1.70	0.69	-0.16	0.26
Beverages	1.59	1.42	0.74	-0.49	0.10
Tobacco Products	1.09	1.71	0.07	-0.11	-0.43
Printing & Publishing	5.26	4.25	0.78	0	0.36
Non-Metallic Mineral Products	1.82	3.04	0.71	-0.43	-1.27
All Medium-Knowledge Manufacturing	2.57	2.34	1.36	-0.63	-0.36

Table 4-2 (Cont'd)

	Growth Rate	Sources of Output Growth			
		Domestic Final Demand	Exports	Import Penetration	Technical Change
1981-86					
Other Transportation Equipment	-4.06	-3.03	0.68	-1.81	-0.93
Other Electrical & Electronic Products	0.52	-0.11	2.30	-1.67	0.05
Primary Metals (Non-Ferrous)	2.86	-0.25	3.63	-0.81	-0.18
Textiles	1.47	1.82	1.22	-2.42	1.09
Paper & Allied Products	2.25	0.88	1.56	-0.53	0.26
Rubber Products	2.44	-0.16	5.17	-1.79	0.16
Plastic Products	6.16	0.80	3.06	-0.42	2.10
Primary Metals (Ferrous)	-2.01	-0.91	1.56	0.61	-2.24
Fabricated Metal Products	0.55	-0.02	2.21	-0.57	-1.68
Motor Vehicles & Parts	10.65	0.63	10.89	-1.27	0.15
Food	1.02	0.73	0.55	-0.40	-0.11
Beverages	0.54	0.90	-0.54	-0.35	0.20
Tobacco Products	-3.73	-3.87	-0.75	0.16	0.04
Printing & Publishing	3.10	1.60	1.36	-0.29	0.16
Non-Metallic Mineral Products	1.17	0.19	1.36	-0.34	-0.30
All Medium-Knowledge Manufacturing	2.75	0.39	3.09	-0.71	-0.20
1986-91					
Other Transportation Equipment	1.34	1.45	-0.86	-0.06	-0.35
Other Electrical & Electronic Products	-2.35	2.31	1.90	-5.06	0.80
Primary Metals (Non-ferrous)	2.27	0.45	3.31	-1.16	0.20
Textiles	-2.56	-0.08	1.91	-3.83	0.55
Paper & Allied Products	-0.13	0.61	1.74	-1.26	0.13
Rubber Products	-2.24	0.85	1.30	-4.98	0.76
Plastic Products	2.27	0.78	1.24	-2.76	0.57
Primary Metals (Ferrous)	-0.40	0.77	1.11	-1.03	1.73
Fabricated Metal Products	-1.11	0.90	-0.06	-1.77	0.55
Motor Vehicles & Parts	0.84	0.10	-0.52	0.71	0.08
Food	0.40	0.72	0.62	-1.16	0.17
Beverages	-1.65	0.17	1.10	-1.59	-0.01
Tobacco Products	-3.21	-2.27	1.48	-2.99	-0.01
Printing & Publishing	-0.23	2.41	0.22	-1.67	-1.16
Non-Metallic Mineral Products	-2.82	1.08	-0.11	-1.80	-1.06
All Medium-Knowledge Manufacturing	-0.05	0.70	0.70	-1.22	0.18

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Plastic products and primary metals (non-ferrous) are the only two medium-knowledge industries that made the list of the top 20 output growth industries over the period 1986-91. These industries benefited mainly from strong export growth, though domestic market expansion and technological change also played positive roles (Table 4-2). Plastic products witnessed strong import competition in the second half of the 1980s, whereas this factor had previously been marginal.

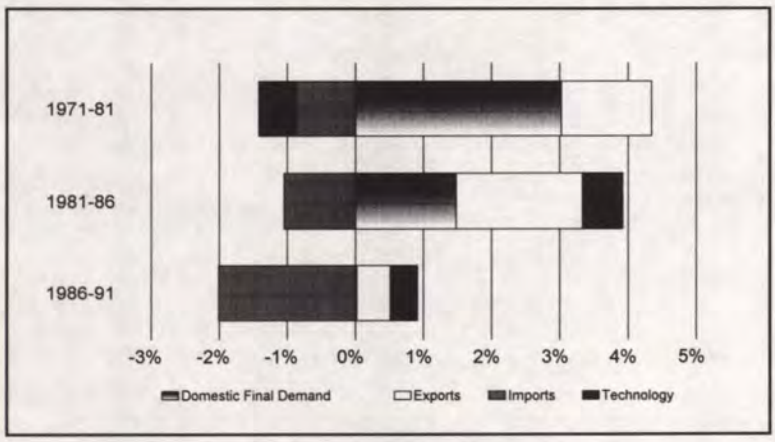
On the other hand, there has been much concern over falling output in medium-knowledge industries such as textiles and steel. Our results show that imports and, to a lesser extent, changing production techniques have been the major factors responsible for the decline in output in these industries. Import penetration was the cause of decline in output in the textile industry in the last part of the sample period, and technological change greatly reduced output growth in the steel industry in the early part of the 1980s.

Low-Knowledge Industries

The results are very different for low-knowledge manufacturing industries. Over the 1971-81 period, most of these industries recorded positive output growth, primarily as a result of changes in domestic demand (for four out of five industries), but exports also helped. However, output in these industries declined at a much faster pace during the 1986-91 period as import penetration caused a particularly severe drain on growth during that period (Chart 4-4). In every industry, import penetration was the largest negative contributor to output growth.

The impact of import penetration has been particularly severe in the other manufacturing industries such as clothing, furniture and fixtures, and leather (Table 4-3).

Chart 4-4
Sources of Output Growth in Low-Knowledge Manufacturing Industries, 1971-91[1]



1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 4-3
Sources of Output Growth in Low-Knowledge Manufacturing Industries, 1971-91[1]

		Sources of Output Growth			
	Growth Rate	Domestic Final Demand	Exports	Import Penetration	Technical Change
1971-81					
Other Manufacturing Products	2.90	4.09	1.23	-1.12	-0.71
Wood	3.66	2.04	2.48	-0.46	-0.88
Furniture & Fixtures	3.32	3.90	1.09	-0.90	-0.11
Clothing	2.29	3.56	0.10	-1.12	-0.23
Leather	1.33	2.80	0.32	-1.60	-0.53
All Low-Knowledge Manufacturing	2.97	3.02	1.32	-0.87	-0.55
1981-86					
Other Manufacturing Products	0.57	2.19	2.10	-1.57	0.43
Wood	4.32	0.70	2.54	0.16	0.89
Furniture & Fixtures	3.39	0.22	2.25	-0.24	0.44
Clothing	1.90	3.17	0.43	-2.68	0.34
Leather	-2.27	1.61	0.86	-4.05	0.11
All Low-Knowledge Manufacturing	2.71	1.48	1.85	-1.05	0.59
1986-91					
Other Manufacturing Products	-0.42	0.85	1.64	-3.38	0.59
Wood	0.04	-0.19	0.17	-0.60	0.49
Furniture & Fixtures	-3.55	2.17	-0.06	-4.21	0.34
Clothing	-2.15	-1.08	0.82	-1.91	0.10
Leather	-9.26	-1.68	0.32	-6.36	0.56
All Low-Knowledge Manufacturing	-1.39	0.02	0.49	-2.01	0.40

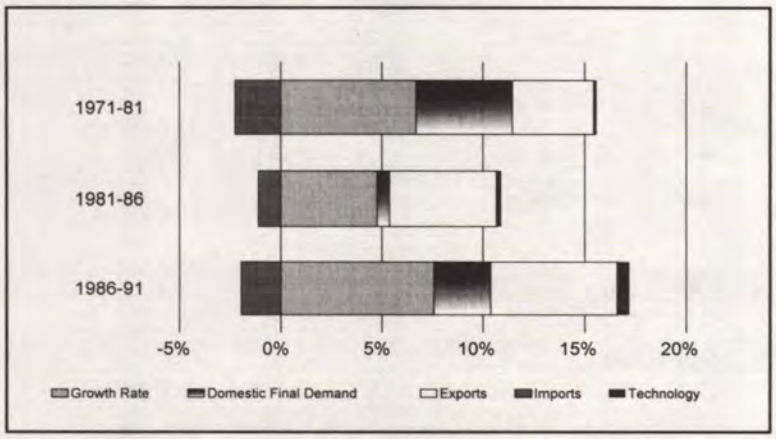
1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Technology Intensity

High-Technology Industries

The high-technology manufacturing industries derived most of their success from export performance, especially in the 1980s (Chart 4-5). Export growth over the period 1986-91 occurred despite the appreciation of the Canadian dollar relative to the U.S. dollar. As with manufacturing as a whole, changes in domestic demand have played a role in the growth of

Chart 4-5
Sources of Output Growth in High-Technology Manufacturing Industries, 1971-91[1]



1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

high-technology industries, but exports now appear to dominate. Again, import penetration limited the growth of these industries.

In the computer and office equipment industry – the industry with the fastest output growth in all sample periods – the expansion of exports was the predominant factor driving output gains. The electrical equipment and aircraft manufacturing industries (except for the 1981-86 period) also benefited from export growth. The pharmaceuticals industry gained mostly from final domestic demand growth. Finally, electrical equipment and appliances recorded negative growth rates in the 1986-91 period as a result of increased import penetration.[16]

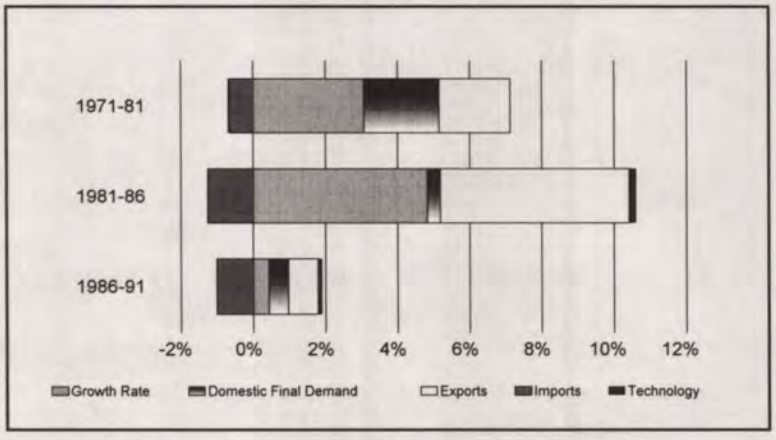
Medium-Technology Industries

Between 1971 and 1981, output growth in medium-technology manufacturing industries came mainly from strong expansion of domestic demand. During the 1980s, exports tended to compensate the adverse effects of import penetration. Changes in production techniques also began to contribute to output growth during this period (Chart 4-6).

Several medium-technology industries do remain among the top growth performers, notably motor vehicles and parts, chemicals, rubber and plastics, and non-ferrous metals. These industries became highly export-dependent during the 1980s, and technological change was also a major factor in their performance.

Whereas the OECD study (1992) found medium-technology manufacturers to be the biggest output-share gainers in Canada over the period 1981-86, we find that over the entire decade, only a handful of medium-tech industries joined the top performers category. These industries gained just over 0.4 percentage point, compared with the 1.4-point gain recorded by

Chart 4-6
Sources of Output Growth in Medium-Technology Manufacturing Industries, 1971-91[1]



1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

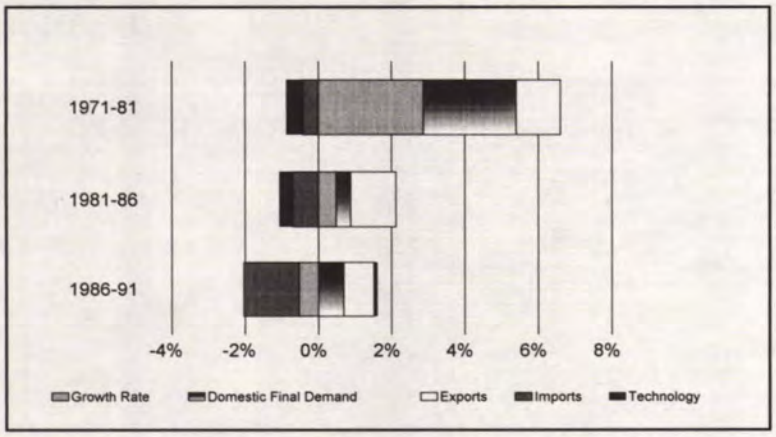
high-technology industries. The motor vehicle industry accounted for virtually all of the medium-technology sector's gain over the decade, while business machines and electronic equipment dominated the high-technology industries. Exports were by far the most important source of growth for both high- and medium-technology industries over the decade.

Low-Technology Industries

The results are very different for low-technology industries. Over the 1971-81 period, most of them recorded strong growth rates, with both domestic demand and, to a lesser extent, exports playing a role. Import penetration and changes in production techniques limited growth in those industries throughout the 1970s and early 1980s, but imports led to a particularly severe slowdown in growth between 1986 and 1991. Rising import penetration likely implies a relative lack of competitiveness in low-technology industries (Chart 4-7).

In the early 1980s, all factors – changes in trade, domestic demand, and technological change – contributed to shifts in the output structure of low-technology industries. From 1986 to 1991, however, import penetration tended to be the dominant factor. Surprisingly, the shipbuilding and repair industry managed to become a leading growth industry during this period. Almost 70 percent of its growth was accounted for by government expenditure.

Chart 4-7
Sources of Output Growth in Low-Technology Manufacturing Industries, 1971-91[1]



1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Skill Intensity

A familiar pattern arises when manufacturing output is examined from the point of view of its skills content: domestic demand is by far the most influential factor affecting growth in the early part of the sample period, giving way to exports by 1986-91. Import competition plays an increasingly important role in the evolution of virtually every industry; while "skilled" industries are usually able to offset increased import competition with strong export performance of their own, "unskilled" industries have suffered output growth contraction due to imports (Table 4-4).

Table 4-4
Gross Output Growth in the Manufacturing Sector, by Level of Skill Intensity, 1971-91[1]

		Sources of Output Growth			
	Growth Rate	Domestic Final Demand	Exports	Import Penetration	Technical Change
1971-81					
Skilled	3.85	2.64	1.72	-0.51	0.01
Unskilled	2.69	2.57	1.67	-0.82	-0.58
1981-86					
Skilled	1.24	0.46	1.86	-0.76	-0.28
Unskilled	3.33	0.33	3.98	-1.08	0.02
1986-91					
Skilled	1.26	1.15	2.03	-1.52	0.01
Unskilled	-0.19	0.50	0.57	-1.21	0.30

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 4-5
Gross Output Growth in the Manufacturing Sector, by Wage Level, 1971-91[1]

Wage Level	Growth Rate	Sources of Output Growth			
		Domestic Final Demand	Exports	Import Penetration	Technical Change
1971-81					
High	4.30	2.39	2.69	-0.63	0.04
Medium	3.30	2.86	1.78	-0.78	-0.49
Low	2.60	2.47	0.94	-0.54	0.25
1981-86					
High	4.15	0.26	5.74	-1.29	-0.21
Medium	1.43	0.22	1.98	-0.56	-0.40
Low	1.19	0.76	1.02	-0.95	0.22
1986-91					
High	1.84	0.68	1.68	-0.58	-0.06
Medium	0.56	1.32	1.48	-1.55	0.17
Low	-0.68	0.43	0.84	-1.97	0.32

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Wage Levels

Within the manufacturing sector, high-wage industries are generally export-oriented. Changing trade patterns, at least throughout the 1980s, have not hurt the high-wage segment of the Canadian manufacturing sector. In the medium- and low-wage segments, however, import competition has generally had net negative effects on output growth (Table 4-5).

The emerging Canadian pattern of exporting high-wage premium goods while importing low-wage goods (observed over the 1980s) is apparently common to developed countries (OECD, 1994).

Sector Orientation

The spectacular growth of science-based industries – computers and office equipment, pharmaceuticals, and aerospace – was particularly evident during the second half of the 1980s. This success has consistently been based on strong export performance (Table 4-6).

Strong export performance and renewed domestic demand contributed to the strong growth of the product-differentiated industries in the second half of the 1980s. Import penetration also began to play a significant role in this group: the electrical equipment and appliances, and communication equipment industries, for example, were adversely affected by this factor.

Table 4-6
Gross Output Growth in the Manufacturing Sector, by Sector Orientation, 1971-91[1]

		Sources of Output Growth			
	Growth Rate	Domestic Final Demand	Exports	Import Penetration	Technical Change
1971-81					
Natural Resource-Intensive	2.47	1.92	0.97	-0.24	-0.21
Labour-Intensive	2.79	3.46	1.07	-0.86	-0.81
Product-Differentiated	4.57	3.86	2.47	-1.50	-0.37
Scale-Intensive	3.27	2.30	1.97	-0.59	-0.21
Science-Based	9.42	4.99	6.12	-2.11	0.80
1981-86					
Natural Resource-Intensive	0.43	0.07	1.34	-0.67	-0.24
Labour-Intensive	0.86	1.30	1.60	-1.57	-0.49
Product-Differentiated	0.35	-0.28	1.44	-1.48	0.10
Scale-Intensive	4.33	0.48	4.59	-0.79	0
Science-Based	7.58	1.42	7.66	-0.70	0.02
1986-91					
Natural Resource-Intensive	0.10	0.54	1.11	-1.29	0
Labour-Intensive	-2.06	0.35	0.57	-2.55	0.47
Product-Differentiated	2.74	2.62	2.76	-2.14	0.34
Scale-Intensive	0.27	0.72	0.71	-0.97	0.09
Science-Based	9.31	2.02	7.76	-1.05	0.48

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Scale-intensive industries recorded strong growth rates between 1971 and 1986 but grew at a slower pace during the last subperiod because of weak exports and strong imports. Although it barely grew, the rubber and plastics industry was the only one to enjoy a significant positive contribution from technology during the 1986-91 period.

Summary

What seems novel about the "new economy" industries – that is, knowledge- and technology-intensive, high-wage, and high-skill industries – is their relatively recent reliance on trade as one of the primary determinants of growth. Whereas in the 1970s and early 1980s the most important factor driving growth was generally domestic demand, we now find exports playing an increasingly important role. Moreover, industries in relative decline – generally those which are in the medium- and low-knowledge and -technology categories – seem to be falling victim to trade-related factors. Domestic demand has become a secondary factor in the prospects of Canadian industries, though high-knowledge industries as a group still depend on it more than any other factor. In general, however, it is those industries which are able to compete in the global arena – industries whose export performance is above average and which tend to be the

leading growth industries. Declining sectors in general have been negatively affected by import competition and lower domestic demand.

The Service Sector

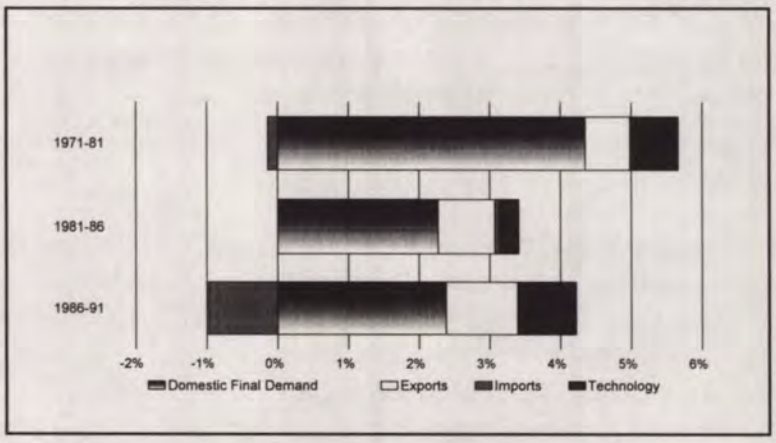
For the service sector, the domestic market is still the dominant force driving economic growth (Chart 4-8). This is a reflection of the fact that services are generally not traded as much as goods although this is rapidly beginning to change. Exports are helping to fuel growth in services while imports are dampening it.

Note that while services account for a very small proportion of direct exports, they provide value-added support to other industries engaged in the production of merchandise exports. The input/output model is an excellent tool for capturing the contribution of services – i.e., transportation, computer support, accounting services, and others that are an integral part of the production and export processes. A recent paper (Cox & Harris, 1991) shows that every dollar of manufactured exports from Canada contains about 38 cents' worth of service sector output.

High-Knowledge Services

In high-knowledge services, output growth has been led by the expansion of domestic demand. This is not surprising, given that these industries are dominated by non-market activities – educational services, health, and social services. However, in business services, which lead the growth rankings in this group, technological change also made significant contributions to output growth (Table 4-7).

Chart 4-8
Sources of Output Growth in the Service Sector, 1971-91[1]



1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 4-7
Sources of Output Growth in High-Knowledge Service Industries, 1971-91[1]

		Sources of Output Growth			
	Growth Rate	Domestic Final Demand	Exports	Import Penetration	Technical Change
1971-81					
Business Services	9.20	4.59	1.22	-0.41	3.60
Educational Services	4.03	4.07	0.10	0.09	-0.01
Health & Social Services	5.80	5.86	0.01	-0.05	0.00
Electric Power Systems	6.53	4.51	1.34	-0.10	0.53
Pipeline Transport	2.78	1.65	-0.77	0.68	1.00
All High-Knowledge Services	7.25	4.67	0.83	-0.17	1.77
1981-86					
Business Services	5.15	1.84	1.27	1.43	0.51
Educational Services	4.86	2.26	0.13	-0.06	-0.01
Health and Social Services	3.42	3.76	0.00	0.00	0.00
Electric Power Systems	3.27	2.22	0.66	-0.12	0.74
Pipeline Transport	2.33	2.06	1.27	0.28	-0.18
All High-Knowledge Services	4.09	2.36	0.81	0.59	0.42
1986-91					
Business Services	6.09	2.47	1.16	-0.71	2.78
Educational Services	3.44	4.23	0.95	-1.17	0.00
Health and Social Services	4.07	3.98	0.01	-0.21	0.01
Electric Power Systems	2.84	2.12	0.10	-0.62	1.29
Pipeline Transport	6.55	1.77	5.30	-0.28	0.62
All High-Knowledge Services	4.76	2.69	0.87	-0.57	1.61

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Utilities – electric power systems and, especially, pipeline transport services – deserve mention for their strong output growth rates throughout the sample period. The main factor for these industries was domestic demand, although exports made significant contributions in the pipeline transport industries during the 1986-91 period.

Medium-Knowledge Services

Between 1971 and 1991, all six medium-knowledge service industries recorded high output growth rates. Again, domestic demand was the major engine of output growth in these industries. Export expansion and changes in technology also contributed to growth in the 1980s, although to a lesser extent than domestic demand. In recreation services, the large positive effect of changes in exports and the negative effect of imports were particularly pronounced in the 1986-91 period (Table 4-8).

Table 4-8
Sources of Output Growth in Medium-Knowledge Service Industries, 1971-91[1]

		Sources of Output Growth			
	Growth Rate	Domestic Final Demand	Exports	Import Penetration	Technical Change
1971-81					
Wholesale Trade	4.76	4.42	0.84	-0.20	-0.48
Finance, Real Estate & Insurance	5.98	4.66	0.42	-0.16	0.88
Services Incidental to Mining	12.71	6.20	0.09	0.13	6.08
Recreation Services	6.73	6.82	0.11	-0.25	0.24
Telecommunications	10.28	6.64	0.77	-0.20	3.14
Gas Distribution Systems	4.05	3.91	0.46	-0.09	-0.14
All Medium-Knowledge Services	6.39	4.97	0.57	-0.17	0.90
1981-86					
Wholesale Trade	4.72	1.73	1.46	-0.17	0.35
Finance, Real Estate & Insurance	4.40	2.90	0.69	-0.09	0.75
Services Incidental to Mining	-3.53	-5.91	0.96	-0.05	0.86
Recreation Services	6.59	4.09	0.19	0.36	0.81
Telecommunications	4.04	3.20	0.84	-0.05	0.32
Gas Distribution Systems	1.23	1.33	0.66	-0.10	-0.83
All Medium-Knowledge Services	4.18	2.26	0.92	-0.09	0.56
1986-91					
Wholesale Trade	3.52	2.82	0.99	-0.52	1.28
Finance, Real Estate & Insurance	2.84	2.97	0.65	-0.85	0.31
Services Incidental to Mining	-1.14	2.69	1.41	-0.50	-5.26
Recreation Services	2.90	1.21	2.49	-2.44	-0.19
Telecommunications	7.09	4.64	0.94	-0.98	2.66
Gas Distribution Systems	1.88	0.77	0.90	-0.46	-0.67
All Medium-Knowledge Services	3.44	3.01	0.90	-0.84	0.68

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

The output growth rates attained by the two medium-knowledge utilities (gas distribution systems and telecommunications) were mainly the result of growth in domestic demand. Technological change also made noticeable contributions to output growth in telecommunications services, though to a lesser extent than domestic demand.

Low-Knowledge Services

Among low-knowledge services, traditional sectors such as personal services, retail trade, and other services enjoyed, in general, strong output growth rates over the sample period, thanks to strong domestic final demand. Within other services, technology also made a notable positive contribution. While the impact of trade was minimal during the first two subperiods, during 1986-91 the effect of both exports and imports on output increased in storage and warehousing services, accommodation and food services, and other service industries. Changes in production techniques also made notable positive contributions to output growth during this period, except in storage and warehousing services (Table 4-9).

Table 4-9
Sources of Output Growth in Low-Knowledge Service Industries, 1971-91[1]

		Sources of Output Growth			
	Growth Rate	Domestic Final Demand	Exports	Import Penetration	Technical Change
1971-81					
Transportation Services	3.98	2.85	1.52	-0.22	-0.23
Storage & Warehousing	2.03	2.48	1.20	-0.14	-1.14
Retail Trade	3.37	3.70	0.15	-0.05	-0.17
Personal Services	6.42	4.12	0.40	0.04	1.19
Accommodation & Food	4.69	4.45	0.12	-0.04	0.10
Other Services	3.53	2.67	0.45	-0.18	0.52
All Low-Knowledge Services	4.06	3.57	0.62	-0.09	-0.02
1981-86					
Transportation Services	2.62	1.32	1.52	-0.08	-0.05
Storage & Warehousing	1.35	1.01	0.20	-0.10	-1.08
Retail Trade	3.30	3.24	0.24	-0.03	-0.01
Personal Services	2.71	4.46	0.57	0.16	-0.05
Accommodation & Food	0.31	0.62	0.17	-0.02	-0.37
Other Services	4.23	1.07	0.76	-0.12	2.51
All Low-Knowledge Services	2.48	2.24	0.68	-0.03	-0.08
1986-91					
Transportation Services	1.23	0.83	1.65	-1.80	0.92
Storage & Warehousing	-0.11	0.74	2.86	-0.46	-3.48
Retail Trade	1.63	1.78	0.25	-0.21	0.13
Personal Services	6.02	3.07	0.62	-0.57	1.05
Accommodation & Food	1.30	0.86	2.82	-3.68	0.85
Other Services	0.91	0.99	1.80	-2.84	1.07
All Low-Knowledge Services	1.93	1.46	1.22	-1.38	0.58

1 Average annual percentages, based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Summary

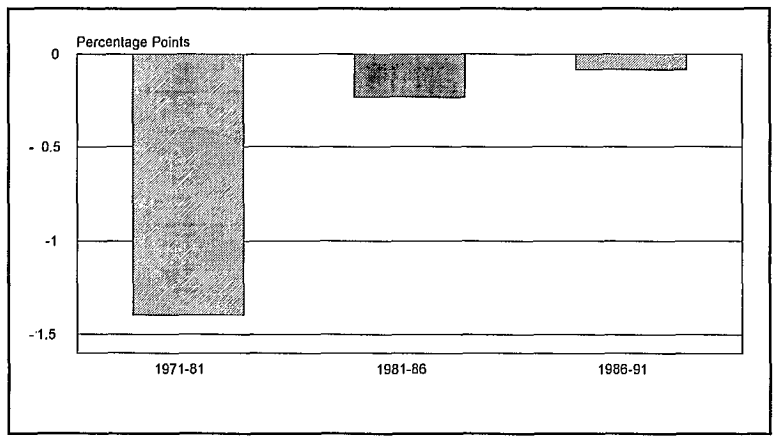
- Structural change has not occurred only in manufacturing but has also been observed in services, where high-knowledge industries have grown more strongly since 1971 than their medium- or low-knowledge counterparts.
- For the service sector, the domestic market is still the dominant force. This reflects the fact that services are not as readily traded as goods. Nonetheless, trade is growing in importance.
- In traditional and high-knowledge services, technical change has become more noticeable.

The Natural Resource Sector

The last sector of the Canadian economy that we examine is the natural resource sector, composed of agriculture, fishing and trapping, forestry, mining, mineral fuels, and quarries and sand pits. This sector has been of great importance to the economy for decades – it currently accounts for just under 10 percent of total output (Table 4-10) – but its relative share has been declining in recent decades, even though the declines was relatively small in the 1980s (Chart 4-9). This sector is predominately composed of medium- and low-knowledge industries.

In each natural resource industries, a trade-related factor explains the recent growth of the industry, be it exports or import displacement. While the major decline factor for these industries in the 1970s was generally poor export performance, it is exports and/or import displacement that propelled them into the top growth rankings during the second half of the 1980s. As with the top performing service and manufacturing sectors examined previously, we find that trade is becoming increasingly important in shaping the industrial structure of the natural resource sector (Table 4-11).

Chart 4-9
Change in Relative Shares of Output, Natural Resource Sector, 1971-91[1]



1 Percentage points based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 4-10
Share of Gross Output in the Natural Resource Sector, 1971-91[1]

	1971-81		1981-86		1986-91	
	1971	1981	1981	1986	1986	1991
Agriculture	3.78	3.13	4.59	4.36	3.43	3.22
Fishing & Trapping	0.17	0.14	0.18	0.18	0.21	0.22
Forestry	1.02	0.89	0.90	0.98	0.93	0.89
Metal Mines	1.61	1.10	1.40	1.33	1.01	1.04
Non-Metal Mines	0.43	0.42	0.58	0.55	0.41	0.43
Mineral Fuels	1.47	1.07	3.57	3.74	2.73	2.95
Quarries, Sand Pits & Mining Services	0.47	0.80	0.85	0.70	0.72	0.59
All Natural Resource Industries	8.95	7.55	12.0	11.84	9.43	9.35

1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Table 4-11
Sources of Gross Output Growth in the Natural Resource Sector, 1971-91[1]

		Sources of Output Growth			
	Growth Rate	Domestic Final Demand	Exports	Import Penetration	Technical Change
1971-81					
Agriculture	2.20	1.71	0.95	-0.34	-0.29
Fishing & Trapping	2.57	0.42	2.98	-0.58	-0.44
Forestry	2.70	1.52	2.38	-0.37	-1.24
Metal Mines	0.22	0.59	1.19	-0.93	-0.44
Non-Metal Mines	4.02	1.00	2.00	0	-0.29
Mineral Fuels	0.83	1.64	-1.90	1.75	-0.79
Quarrying, Sand Pits & Mining Services	9.88	5.25	0.12	0.08	4.65
1981-86					
Agriculture	1.37	1.19	0.33	-0.17	-0.30
Fishing & Trapping	2.39	0.59	4.21	-0.82	-1.66
Forestry	4.27	0.94	2.37	-0.14	0.49
Metal Mines	1.42	-0.07	1.19	0.33	-0.47
Non-Metal Mines	1.14	0.22	1.23	-0.55	-0.41
Mineral Fuels	3.43	-0.09	5.13	-0.12	-0.90
Quarrying, Sand Pits & Mining Services	-1.68	-4.81	0.86	0.08	0.86
1986-91					
Agriculture	0.72	-0.12	1.79	-0.62	0.10
Fishing & Trapping	3.61	1.65	0.13	1.69	0.93
Forestry	1.08	0.31	0.13	-0.79	-0.04
Metal Mines	2.62	0.34	2.07	-0.13	-0.66
Non-Metal Mines	3.14	0.47	1.45	1.14	-0.03
Mineral Fuels	3.58	0.69	4.82	-2.23	0.05
Quarrying, Sand Pits & Mining Services	-2.11	2.11	1.25	-0.72	-4.10

1 Percentages based on data expressed in 1971 prices (1971-81), 1981 prices (1981-86), and 1986 prices (1986-91).

Low-knowledge primary industries – agriculture, forestry, and quarrying – all seem to be experiencing long-term problems, losing output share in at least two subperiods. A variety of factors explain these declines. Agriculture, perennially in decline, was buoyed by strong exports during the second half of the 1980s, but low domestic demand kept its growth rate below average. Quarrying, sand pits, and mining services enjoyed strong growth ranking in 1971-81 but dropped dramatically as a result of low domestic demand and technology effects in the 1980s. Likewise, forestry enjoyed strong growth thanks to demand and exports during the first half of the 1980s, but as a result of low exports and import penetration, it sank in the growth rankings during the second half of the decade (Table 4-11).

Thus declaring natural resources a declining sector in Canada fails to recognize the above-average performance of several of the industries that comprise this sector: fishing and trapping, along with medium-knowledge industries such as metal and non-metal mining, and mineral fuels all appear among the leading industries in terms of growth rates and share gains in the latest decomposition period. On the other hand, industries such as agriculture and quarrying seem to be in long-term decline, while the slowdown of the forestry industry seems more recent.

5. CONCLUSIONS

The main principal objective of this paper was to examine the changing industrial structure of the Canadian economy over the period 1970-91. While a great number of results and conclusions have been presented in the course of the analysis, several major outcomes deserve to be highlighted.

Structural change is evident at the aggregate level. Canada, like all of its major trading partners, has experienced an ongoing shift away from manufacturing-based industries towards services. Changing consumer demand patterns have played a major role in de-industrialization, but other factors have also been at work.

At a more disaggregated level, the industries that led growth in the Canadian economy during the 1970s – computers and office equipment; communication equipment and semiconductors; communication services; real estate and business services; community, social, and personal services; pharmaceuticals; electricity, gas, and water; and finance and insurance – remain growth leaders. These industries are fairly evenly divided between manufacturers and service producers.

Contrary to a widespread perception, the speed of change in the economy does not appear to be accelerating. While Canada has clearly experienced important structural shifts over the period studied here, the pace of change seems to have peaked in the early 1980s. That is, structural change is proceeding no more rapidly today than in the 1970s. At the same time, the main factors underlying structural change seem to have evolved. The contribution of trade-related factors to both the growth or the decline of Canadian industries has become increasingly important, replacing domestic demand.

The most important messages arising from this analysis come from the grouping of industries based on industry characteristics such as knowledge intensity, technological sophistication, the average level of skills of the workforce, employee compensation levels, and the like. Canada's industrial structure is becoming increasingly knowledge-based and technology-intensive, with its competitive advantage rooted in innovation and ideas – the foundations of the "new economy" paradigm. Our empirical findings point to this shift in structure on several different levels.

Knowledge intensity is the first indicator of industrial structural change. The economy is moving up the knowledge scale, and this has been going on since the early 1970s.

High-knowledge industries have outpaced their medium- and low-knowledge counterparts and as a result have gained output share at their expense. Exports have generally supplanted domestic demand as the main growth factor for the high-knowledge group.

Within the manufacturing sector, *technological intensity* is an indicator of structural change. Canada has experienced a shift towards those industries classified as high-technology,

and again this evolution has been apparent as far back as the 1970s. Though medium-technology output shares boomed in the first half of the 1980s (thanks to the motor vehicle industry), high-technology has continued to gain in the most recent subperiod while the other two groups have shrunk.

Exports became an increasingly important factor of change in high-technology industries. Rising imports have contributed to the loss of output share of the medium- and especially low-technology sectors over the second half of the 1980s.

The *skills intensity* of output in the manufacturing sector is another factor of structural change. Mainly through their export performance, industries that use more advanced labour skills have, over time, increased their relative importance as compared to those which employ lower skilled workers. Imports have contributed to the loss of output share among the latter group.

Skill requirements, of course, have implications for the *wages* received by workers in a particular sector or industry. Dividing manufacturing industries into high-, medium-, and low-wage categories reveals that structural change also varies depending on these wage groupings. The high-wage sector has relied increasingly upon exports for growth over time. High-wage producers have gained share at the expense of medium- and especially low-wage manufacturers, the latter having suffered the greatest share losses to import competition.

Concluding the analysis of structural change in manufacturing, we look at *sectoral orientation* and divide manufacturers into natural resource-intensive, labour-intensive, product-differentiated, scale-intensive, and science-based groups. The science-based group turned out to be the only one posting consistent gain shares throughout the period under study. As well, product-differentiated manufacturers gained slightly in the late 1980s. Exports were the main factor driving both of these groups in the second half of the 1980s, with demand also playing an important role. Scale-intensive manufacturers enjoyed strong growth through the 1970s and early 1980s, but grew at a slower pace at the end of the decade, as a result of weak exports and strong import competition.

Structural change has not only occurred in manufacturing: the same outcome can be observed in the *service sector*. Here, it is the most innovative industries which have increased their output share. High-knowledge services have grown more strongly since 1971 than medium- and low-knowledge industries. In this sector, the domestic market remains the dominant force, reflecting the fact that services are not as readily traded as goods. Nonetheless, trade is growing in importance. In traditional and high-knowledge services, technical change is becoming more noticeable.

While *natural resources* seem to be in general decline, a closer examination at the industry level reveals the above-average performance of several industries that make up this sector: fishing and trapping, metal and non-metal mining, and mineral fuels all appear among the leading industries in the second half of the 1980s. On the other hand, industries such as

agriculture and quarrying seem to be in long-term decline, while the decline of the forestry industry is a more recent development. All of the top resource industries have a trade-related factor underlying their above-average performance, and in most cases, they experience strong growth despite low or even negative domestic demand.

Finally, the "new economy" hypothesis is largely supported in this study. There seems to be clear evidence that the structure of output in Canada is shifting towards high-knowledge and high-technology industries and that an increasing proportion of output is accounted for by industries that have higher skill requirements and pay higher wages. However, unlike Beck (1992), we do not find this to be a new phenomenon but one with roots at least as far back as the early 1970s. Our findings do support the notion of clustering of certain high-technology/high-knowledge industries, documented by the OECD and Beck in the Canadian data.

What does seem novel about the dynamics of the "new economy" industries is their relatively recent reliance on trade as one of the primary determinants of growth. Whereas in the 1970s and early 1980s the most important factor underlying growth was domestic demand, we find that exports have played an increasingly important role in recent years. In addition, trade-related factors seem to be hastening the slowdown of industries that are experiencing a relative decline (generally medium- and low-knowledge and/or -technology industries).

Findings for the period 1986-91 show that the Canadian industrial structure is shifting, at least in part, from resource-based and scale-based manufacturing to knowledge-intensive industries, in which competitiveness depends mainly upon innovation. The policy implications are quire clear. The best contribution government can make is to invest in knowledge by producing, distributing, and using knowledge and information.

Domestic demand has become a secondary factor in the prospects of Canadian manufacturing industries, though the high-knowledge group still depends on it more than on any other factor. However, in general it is those manufacturing and resource industries that are able to compete in the global arena – that is, those whose export performance is above average – which tend to enjoy the highest growth rates. Low-growth industries in these sectors have import competition and weak domestic demand to blame for their poor performance.

Service industries, which have been outperforming all other sectors in terms of growth rates and output share gains, have been driven mainly by domestic demand. It is clear that the shift in consumer demand from manufactured products to services has mainly benefited the dynamic service providers and hastened the relative decline of those manufacturing industries unable to compensate through increased exports. The leaders – technology- and knowledge-intensive industries requiring highly skilled employees and paying high wages – have succeeded despite generally lower domestic demand by competing on world markets and fending off the strong import competition of the late 1980s. Industries that have seen their domestic demand fall and import competition rise and that have not achieved higher exports have gone into relative decline.

APPENDIX A

Table A-1
Average R&D Activity by Industry, 1984-88[1]

	R&D Intensity		R&D Personnel per Worker		Professional R&D Personnel per Worker	
	Percent	Rank	Percent	Rank	Percent	Rank
Scientific & Professional Equipment	27.88	1	3.14	9	1.65	9
Communication & Other Electronic Equipment	17.14	2	19.38	1	11.41	1
Aircraft & Parts	10.89	3	11.17	3	4.92	3
Computer & Related Services	9.77	4	6.36	5	3.57	4
Business Machines	9.33	5	15.73	2	9.36	2
Engineering & Scientific Services	8.62	6	4.99	7	2.70	7
Pharmaceutical & Medical Products	3.54	7	5.39	6	2.88	6
Electrical Power	1.21	9	1.98	12	0.91	12
Other Chemical Products	0.96	10	3.16	8	1.76	8
Machinery	0.95	11	1.68	14	0.64	14
Refined Petroleum & Coal Products	0.85	14	7.94	4	3.41	5
Management Consulting Services	0.53	17	0.43	27	0.22	24
Other Transportation Equipment	1.22	8	2.25	11	0.94	11
Other Electrical & Electronic Products	0.90	12	1.69	13	0.87	13
Primary Metals (Non-Ferrous)	0.87	13	2.57	10	0.97	10
Textiles	0.60	15	0.84	18	0.38	18
Communications	0.58	16	0.75	19	0.50	16
Paper & Allied Products	0.43	18	0.89	17	0.38	17
Mining	0.40	19	0.92	16	0.37	19
Rubber	0.30	20	0.59	21	0.31	20
Plastics	0.28	21	0.46	23	0.19	26
Primary Metals (Ferrous)	0.28	22	0.53	22	0.27	21
Non-Metallic Mineral Products	0.26	23	0.44	24	0.20	25
Wholesale Trade	0.25	24	0.25	29	0.12	29
Crude Petroleum & Natural Gas	0.24	25	1.01	15	0.53	15
Fabricated Metal Products	0.21	27	0.37	28	0.17	28
Motor Vehicles & Parts	0.20	28	0.65	20	0.24	22
Beverages & Tobacco	0.15	31	0.43	26	0.18	27
Finance, Insurance & Real Estate	0.09	34	0.21	32	0.08	33
Other Utilities	0.09	35	0.14	36	0.09	32
Services Incidental to Mining	0.09	36	0.15	34	0.07	35
Other Services	0.05	39	0.03	41	0.02	40

Table A-1 (cont'd)

	R&D Intensity		R&D Personnel per Worker		Professional R&D Personnel per Worker	
	Percent	**Rank**	**Percent**	**Rank**	**Percent**	**Rank**
Printing & Publishing	0.04	41	0.07	38	0.04	38
Construction	0.01	43	0.02	42	0.01	42
Fishing & Trapping	0.21	26	0.11	37	0.05	37
Other Manufacturing Industries	0.18	29	0.22	31	0.10	31
Food	0.17	30	0.44	25	0.22	23
Wood	0.13	32	0.24	30	0.11	30
Furniture & Fixtures	0.11	33	0.16	33	0.07	36
Logging & Forestry	0.08	37	0.14	35	0.08	34
Transportation & Storage	0.06	38	0.06	39	0.03	39
Agriculture	0.05	40	0.04	40	0.01	41
Retail Trade	0.02	42	0.01	43	0.01	43

1 Agriculture, fishing and trapping, and logging and forestry: 1985-88 averages. Here, other manufacturing industries include clothing and leather, and "other manufacturing products industries." Other services include other business services and personal services. Gross output and employment in 1986 are used for the scientific and professional equipment and other manufacturing industries. Gross output for computer and related services, engineering and scientific services, and management and consulting services is approximated by using their employment shares of the business service sector.

Source: Lee & Has, 1996.

Table A-2
Human Capital by Industry, 1986

	Proportion of Workers with Postsecondary Education		Proportion of Knowledge Workers		Proportion of Scientists & Engineers per Worker	
	Percent	**Rank**	**Percent**	**Rank**	**Percent**	**Rank**
Scientific & Professional Equipment	45.3	16	30.7	13	12.6	10
Communication & Other Electronic Equipment	51.4	13	38.7	8	21.9	4
Aircraft & Parts	50.5	14	26.1	16	14.8	9
Computer & Related Services	69.2	3	62.2	3	42.0	2
Business Machines	59.6	7	44.6	7	21.2	5
Engineering & Scientific Services	74.9	2	75.4	1	62.1	1
Pharmaceutical & Medical Products	51.7	12	34.5	11	10.0	12
Electrical Power	59.2	8	29.7	14	18.2	6
Other Chemical Products	44.6	18	28.0	15	11.2	11
Machinery	45.4	15	22.1	18	8.5	15
Refined Petroleum & Coal Products	53.6	11	33.9	12	15.6	8
Management Consulting Services	67.4	4	62.0	4	9.1	13
Educational Services	76.4	1	69.7	2	2.3	35
Health & Social Services	65.6	5	61.8	5	0.7	50
Pipeline Transportation	54.9	10	36.1	10	16.0	7
Other Business Services	57.0	9	37.8	9	1.3	42
Other Transportation Equipment	45.3	17	15.0	31	6.3	20
Other Electrical & Electronic Products	33.9	35	19.0	23	7.9	18
Primary Metals (Non-Ferrous)	40.0	22	16.0	29	8.2	16
Textiles	23.3	49	11.5	42	2.7	31
Communications	37.6	25	17.6	26	5.3	22
Paper & Allied Products	35.6	29	12.3	40	4.6	25
Mining	40.5	20	14.2	35	7.9	19
Rubber	31.0	37	14.4	32	4.9	24
Plastics	26.2	44	14.0	37	2.9	29
Primary Metals (Ferrous)	34.5	32	12.5	39	6.3	21
Non-Metallic Mineral Products	28.6	42	14.0	36	3.4	28
Wholesale Trade	35.1	30	18.9	24	1.9	39
Crude Petroleum & Natural Gas	61.6	6	46.6	6	24.7	3
Fabricated Metal Products	38.1	24	14.4	33	4.1	27
Motor Vehicles & Parts	28.8	41	11.2	43	4.4	26
Food	23.9	47	10.8	44	2.1	37
Beverages	32.0	36	15.8	30	2.8	30
Tobacco	34.5	31	16.5	28	5.2	23

Table A-2 (cont'd)

	Proportion of Workers with Postsecondary Education		Proportion of Knowledge Workers		Proportion of Scientists & Engineers per Worker	
	Percent	**Rank**	**Percent**	**Rank**	**Percent**	**Rank**
Finance, Insurance & Real Estate	44.0	19	25.2	17	2.6	32
Other Utilities	36.6	27	18.6	25	2.1	38
Services Incidental to Mining	34.4	33	21.3	19	9.0	14
Other Services	37.3	26	16.5	27	0.8	49
Printing & Publishing	38.4	23	21.0	21	1.3	43
Construction	36.5	28	9.9	47	2.3	34
Amusement & Recreational Services	34.2	34	14.2	34	0.9	48
Fishing & Trapping	19.8	53	4.7	54	2.2	36
Other Manufacturing Products	29.9	38	20.6	22	1.7	40
Wood	25.3	46	7.2	51	1.2	44
Furniture & Fixtures	26.1	45	10.1	46	1.5	41
Logging & Forestry	29.6	39	12.3	41	8.0	17
Transportation	29.0	40	8.9	50	2.3	33
Storage & Warehousing	23.4	48	21.2	20	1.0	46
Agriculture	21.5	50	10.6	45	0.5	51
Retail Trade	28.1	43	13.1	38	0.3	53
Personal Services	40.5	21	3.4	55	0.1	55
Quarries & Sand Pits	20.6	51	9.3	49	1.0	47
Accommodation, Food & Beverage Services	20.0	52	9.4	48	0.1	54
Clothing	16.2	54	6.7	53	0.4	52
Leather	14.5	55	6.8	52	1.0	45

Source: Lee & Has, 1996.

APPENDIX B

Table B-1
Classification of Manufacturing Industries at the 22-Industry Level[1]

	Technology Intensity	Wage Intensity	Skill Intensity	Competitiveness Factor
Food, Beverages & Tobacco	LT	LW	SK	NRI
Textiles, Clothing, Footwear & Leather	LT	LW	USK	LI
Wood, Wood Products & Furniture	LT	LW	USK	NRI
Paper, Paper Products & Printing	LT	MW	SK	SI
Chemicals	MT	HW	SK	SI
Pharmaceuticals	HT	HW	SK	SB
Petroleum Refining & Products	LT	HW	SK	NRI
Rubber & Plastics	MT	MW	USK	SI
Non-Metallic Mineral Products	LT	MW	USK	NRI
Iron & Steel	LT	MW	USK	SI
Non-Ferrous Metals	MT	MW	USK	NRI
Fabricated Metal Products	LT	MW	SK	LI
Non-Electrical Equipment & Appliances	MT	MW	USK	PD
Computers & Office Equipment	HT	HW	SK	SB
Electrical Equipment & Appliances	HT	LW	USK	PD
Communication Equipment & Components	HT	MW	SK	PD
Shipbuilding & Repair	LT	MW	USK	SI
Other Transportation Equipment	MT	LW	USK	SI
Motor Vehicles & Parts	MT	HW	USK	SI
Aircraft Manufacturing	HT	HW	SK	SB
Scientific & Photographic Equipment	HT	MW	SK	SB
Other Manufacturing Industries	MT	LW	USK	LI

1 Technology intensity: LT (low-technology), MT (medium-technology), HT (high-technology).
Wage intensity: LW (low-wage), MW (medium-wage), HW (high-wage).
Skill intensity: SK (skilled), USK (unskilled).
Sector Orientation: NRI (Natural resource-intensive), LI (Labour-intensive), PD (Product-differentiated), SI (Scale-intensive), SB (Science-based).

Source: OECD, 1994.

APPENDIX C

Table C-1
Sources of Output Growth, 111 Industries, 1986-91[1]

		Sources of Output Growth			
	Growth Rate	Domestic Final Demand	Exports	Import Penetration	Technical Change
Natural Resource Sector					
Agriculture	0.72	-0.12	1.79	-0.62	0.10
Fishing & Trapping	3.61	1.65	0.13	1.69	0.93
Forestry	1.08	0.31	0.13	-0.79	-0.04
Metal Mines	2.62	0.34	2.07	-0.13	-0.66
Non-Metal Mines	3.14	0.47	1.45	1.14	-0.03
Mineral Fuels	3.58	0.69	4.82	-2.23	0.05
Quarrying, Sand Pit & Mining Services	-2.11	2.11	1.25	-0.72	-4.10
Manufacturing Sector					
Meat & Poultry Products	0.19	-0.02	0.65	-1.80	1.00
Fish Products	0.98	1.49	1.35	-0.74	0.11
Fruits & Vegetables	2.89	2.51	0.38	-0.40	0.46
Dairy Products	-0.88	0.10	0.16	-0.42	-0.90
Feed Industry	-1.15	0.61	1.48	-1.91	-0.32
Miscellaneous Food Products	1.15	1.17	0.64	-1.14	-0.03
Bread & Other Bakery Products	0.28	1.26	0.30	-0.98	0.43
Beverages	-1.65	0.17	1.10	-1.59	-0.01
Tobacco Products	-3.21	-2.27	1.48	-2.99	-0.01
Rubber Products	-2.24	0.85	1.30	-4.98	0.76
Footwear	-9.57	-2.58	0.45	-5.73	0.27
Plastic Products	2.27	0.78	1.24	-2.76	0.57
Leather Tanneries	-9.95	-0.85	-1.51	-8.17	2.26
Miscellaneous Leather & Allied Products	-7.58	0.97	1.28	-7.22	0.26
Man-Made Fibre Yarn & Woven Cloth	-3.44	-0.42	3.18	-4.44	0.73
Wool Yarn & Woven Cloth	-6.05	-0.60	2.03	-1.96	-0.53
Miscellaneous Textile Products	0.02	0.41	1.27	-2.63	0.69
Carpet, Mat & Rug	-5.41	0.21	0.62	-5.38	0
Clothing, exc. Hosiery	-2.23	-1.13	0.86	-1.99	0.10
Broad-Knitted Fabrics	-3.19	-0.89	1.24	-5.47	0.77
Hosiery	-0.81	-0.25	0.10	-0.47	0.10
Sawmills, Planing & Shingle Mills	0.17	0.12	0.24	-0.39	-0.03
Veneer & Plywood	-1.34	0.12	0.49	-0.71	-0.74
Sash, Door & Other Millwork	0.11	-1.21	0.49	-1.11	2.46

Table C-1 (cont'd)

		Sources of Output Growth			
	Growth Rate	Domestic Final Demand	Exports	Import Penetration	Technical Change
Wooden Boxes & Coffins	-0.72	-0.67	0.52	-0.55	1.24
Other Wood Industries	0.32	0	-1.51	-0.73	0.15
Household Furniture	-6.04	-1.74	2.75	-5.75	0.82
Office Furniture	-3.88	4.25	-3.07	-1.98	0.07
Other Furniture & Fixtures	-0.27	5.42	-1.28	-3.98	-0.05
Pulp & Paper	-0.08	0.43	1.84	-0.91	-0.32
Asphalt Roofing	-3.43	0.34	-0.34	-1.94	1.96
Paper Boxes & Bags	-0.71	0.90	1.09	-2.10	0.76
Other Converted Paper Products	0.83	1.64	2.25	-2.70	2.21
Printing & Publishing	-0.29	2.41	0.18	-1.64	-1.13
Platemaking, Typesetting & Bindery	0.39	2.43	0.53	-2.03	-1.44
Primary Steel	-2.13	0.74	1.13	-0.98	0.62
Steel Pipe & Tube	10.12	1.88	2.99	-1.49	9.15
Iron Foundries	-0.12	-0.55	-1.83	-0.81	0.92
Non-Ferrous Smelting & Refining	3.30	0.37	3.32	-0.57	0.13
Aluminum Rolling, Casting & Extruding	2.60	0.56	4.24	-2.62	2.17
Copper Rolling, Casting & Extruding	-11.10	1.85	-0.33	-6.51	-5.80
Other Metal Rolling, Casting, etc.	-1.35	0.34	3.48	-1.63	0.36
Power Boiler & Structural Metals	-1.20	1.93	-0.75	-1.09	1.10
Ornamental & Architectural Metal Products	3.78	0.56	0	-0.99	1.74
Stamped, Pressed & Coated Metals	-3.85	0.40	-0.21	-1.74	-0.22
Wire & Wire Products	-5.90	0.96	-1.04	-2.48	0.08
Hardware, Tool & Cutlery	-2.07	0.71	0.56	-1.20	-0.28
Heating Equipment	-4.14	0.60	-0.62	-2.82	0.91
Machine Shops	4.21	0.98	0.75	-1.42	0.75
Other Metal Fabricating	4.12	1.11	1.43	-3.49	1.45
Agriculture Implements	-2.69	-3.51	-0.81	5.15	0.07
Commercial Refrigeration Equipment	-1.44	0.88	1.68	-2.72	2.72
Other Machinery & Equipment	-1.20	2.27	0.17	-1.36	-0.27
Aircraft & Aircraft Parts	7.24	1.03	4.96	-0.12	0.68
Motor Vehicles	1.48	0.04	0.70	-0.32	0.07
Trucks, Bus Bodies & Trailers	-6.14	2.09	-2.69	-3.26	0.56
Motor Vehicle Parts & Accessories	0.19	0.03	-2.70	3.08	0.06
Railroad Rolling Stock	-1.69	-2.21	-0.46	0.37	0.77
Shipbuilding & Repair	5.95	5.10	-1.83	1.19	-1.79
Miscellaneous Transportation Equipment	-1.28	2.26	0.23	-3.62	0.07
Small Electrical Appliances	-7.30	0.55	1.51	-7.91	0.55

Table C-1 (cont'd)

		Sources of Output Growth			
	Growth Rate	**Domestic Final Demand**	**Exports**	**Import Penetration**	**Technical Change**
Major Appliances (Electrical & Non-Electrical)	-8.22	0.28	-0.45	-5.53	0.12
Record Players, Radios & TV Receivers	-6.05	-0.55	5.21	-2.67	0.74
Electronic Equipment	13.54	4.49	7.46	-0.58	0.43
Office, Store & Business Machines	21.76	1.72	19.43	-0.98	0.29
Communications, Energy Wire & Cable	-0.16	2.88	1.55	-3.27	-0.54
Other Electrical & Electronic Products	-0.19	3.42	2.18	-5.62	1.53
Clay Products	-11.82	0.45	-0.91	-3.92	-2.80
Cement	-3.41	1.82	-2.18	-1.18	-1.80
Concrete Products	-3.26	0.70	-0.51	-0.47	-1.51
Ready-Mix Concrete	-0.12	2.45	0.06	-0.12	-2.44
Glass & Glass Products	-4.65	-0.44	2.67	-5.17	-0.87
Non-Metallic Mineral Products, n.e.c.[2]	-2.00	0.96	-1.02	-1.42	0.81
Refined Petroleum & Coal Products	0.85	0.79	2.00	-1.06	-0.62
Industrial Chemicals, n.e.c.	0.19	0.98	3.21	-3.10	-0.33
Plastics & Synthetic Resins	2.78	0.65	5.26	-4.88	1.56
Pharmaceutical & Medical Products	3.79	4.06	0.48	-0.66	0.10
Paints & Varnishes	-0.58	1.47	1.04	-2.87	-1.86
Soaps & Cleaning Compounds	-1.06	1.79	1.24	-3.15	0.05
Toilet Preparations	-1.60	3.13	1.79	-6.21	0.31
Chemicals & Chemical Products, n.e.c.	-2.32	0.64	1.01	-1.79	-0.60
Jewellery & Precious Metals	-0.58	-1.19	6.76	-2.14	0.07
Sporting Goods & Toys	-3.30	1.08	0.62	-5.59	-0.31
Signs & Displays	3.09	-0.10	-0.55	-0.60	1.97
Other Manufacturing Industries	0.50	1.77	2.97	-3.65	0.90
Construction Industry					
Construction	2.00	2.05	0.12	-0.10	-0.04
Service Industries					
Air Transport & Incidental Services	-0.28	1.06	3.27	-5.93	1.43
Railway Transport	-0.05	0.62	1.27	-0.86	-0.78
Water Transport & Related Services	-0.12	1.19	1.42	0.66	-3.18
Truck & Other Transport	2.86	0.85	1.26	-0.96	2.29
Urban Transit Systems	-2.82	-0.67	0.72	-1.40	-1.58
Pipeline Transport	6.55	1.78	5.30	-0.28	0.62
Storage & Warehousing	-0.11	0.74	2.86	-0.46	-3.48
Telecommunication Broadcasting	3.81	3.45	0.66	-0.82	0.53

Table C-1 (cont'd)

		Sources of Output Growth			
	Growth Rate	**Domestic Final Demand**	**Exports**	**Import Penetration**	**Technical Change**
Telecommunication Carriers	7.84	4.91	1.01	-1.01	3.15
Electric Power Systems	2.84	2.12	0.10	-0.62	1.29
Gas Distribution Systems	1.88	0.77	0.90	-0.46	-0.67
Wholesale Trade	3.52	2.82	0.99	-0.52	1.28
Retail Trade	1.63	1.78	0.25	-0.21	0.13
Finance, Real Estate & Insurance	2.84	2.97	0.65	-0.85	0.31
Services	4.25	1.95	1.69	-1.77	1.57
Educational Services	3.44	4.23	0.95	-1.17	0
Private Hospitals	2.27	2.25	-0.02	-9.09	0
Other Health Services	4.11	4.02	0.01	-0.01	0.01

1 Average annual percentages, based on data expressed in 1986 prices.
2 Not elsewhere classified.

APPENDIX D

Output Growth Decomposition Methodology

The study examines the changes in the sectoral composition of gross output in industries using Statistics Canada's input/output model. The input/output model is a detailed accounting framework of the Canadian economy that captures the flows of goods and services among industries and consumers at relatively detailed industry and commodity levels.

The model, as an accounting framework, can be described as a series of rectangular input/output tables. At the most detailed level, the Canadian input and output tables consist of 216 industries by 627 commodities (including primary inputs and various margins).[17] Each row in the input/output table describes the *direct* flow of an industry's output to intermediate consumption by other industries (and itself) as well as to the components of final demand. The final-demand table contains information on consumption spending by households, investment spending by businesses, government expenditure on goods and services, exports, and final and intermediate imports. The final-demand table also includes non-tax government revenues. Each column in the input/output table represents the intermediate-input production recipe for a particular industry (for details, see Poole, 1993).

The model exploits the interindustry linkages of the input/output tables to track the total production of goods and services in the business sector in order to satisfy a change in final demand. It indicates which industries were directly responsible for meeting the demand and how much of that demand was "leaked" off to foreign imports and other "leakages" such as inventories and government services. This is referred to as the *direct effects*. The direct suppliers, in turn, purchase goods and services from other industries as inputs. This process continues until the model has identified all the indirect commodities in the full chain of production process. The accumulation of these rounds of impacts is referred to as the *indirect effects*. The direct and indirect effects are combined to form the *total effects* (Poole, 1993).

The input/output model makes it possible to decompose changes in output of the business sector into various components: changes in final demand, exports, imports, and changes in technology (as captured by changes in input/output coefficients). In this paper, we have used input/output tables aggregated at the 111-industry level to decompose changes in gross output into five sources of change:

1. Change due to final domestic demand – i.e., changes in personal consumption, investment, and government expenditures.
2. Change due to exports.
3. Change due to imports – i.e., changes due to imports of final goods and of intermediate inputs.
4. Change in production techniques – i.e., changes in input/output coefficients.
5. Change due to other factors – i.e., changes due to market shares and to other leakages in the substitution of final demand and intermediate goods.

The methodology takes no account of dynamic relationships between variables. For example, the input/output model does not account directly for changes in relatives prices, interest rates, money supply, or many more variables present in typical macroeconomic models. The five sources of change listed above can probably be better described as concurrent changes, observed with the changes in gross output by the business sector, which themselves result from a whole range of socio-economic changes. While there is a link between the five terms and the corresponding changes in gross output, the model does not attempt a full causal measurement effect.

Change in gross output can be measured in three different ways:

1) The first measure gives the **absolute change** in output by sector between a comparative year (T) and a base-year (t):

$$g_T - g_t$$

where g is a vector of gross output by sector. From these differences, it is easy to identify the growing and shrinking industries over the period. By itself, this indicator is of *limited* value as it does not indicate the relative importance of each industry.

2) The second measure of change – **differences in output growth rates** – referred to as the *growth rate indicator*, is a commonly used indicator of change. This is a more meaningful indicator in that it provides relative comparisons among industries:

$$100 \times [(g_T/g_t)^{1/T-t} - 1]$$

3) The third measure indicates the relative importance of each sector with respect to the overall growth of the economy. It is referred to as the **relative-share indicator**. It measures change relative to the average rate of growth for the economy.

$$100 \times [(g_T - \lambda g_t) / \Sigma g_T] \quad \text{where } \lambda = \Sigma g_T / \Sigma g_t$$

where variable λ is the trend of output growth between the two periods. A positive relative-share indicator implies that the sector grew at a faster rate than the overall economy; the opposite is true when values are negative. Magnitudes take into account the relative importance of the sector within the economy.

This paper reports the last two indicators of change – the growth rate and the relative-share indicators. These two measures provide a useful description of the structural change of the economy between two periods. Because the focus is on long-term changes in output as opposed to cyclical movements, the analysis is conducted over a relatively long period (1971-91).

Unfortunately, the input/output tables are *not* available on a consistent constant-dollar basis over the entire period 1971-91, but only for subperiods within that time span. As a result, we had to break down our analysis into three subperiods – 1971-81, 1981-86, and 1986-91.

Mathematical Derivation of the Growth Decomposition Model

This appendix presents the mathematical expressions and derivations used to calculate the various growth decomposition indicators reported in the paper. While based on OECD (1992), our model extends the decomposition to the most disaggregate input/output model available for Canada and takes into account the exhaustive set of model parameters. For example, the following model takes into account all the information that the rectangular Canadian input/output tables contain.

The Structural Input/Output Model[18]

Here, we present the basic definitions, the equilibrium condition, and other relations of the structural model. The model is based on the constant prices Canadian input-output tables.

The total demand for commodities d_t can be broken down into its major components:

$$d_t=d_p+e_c+\bar{e}+x_D^*+x_R^* \tag{1}$$

where d_p is the vector of intermediate demand (for the production process); e_c is the personal consumption vector, $\bar{e}$ is the rest of domestic consumption; x_D^* is the vector of domestic exports; and x_R^* is the vector of re-exports.

The intermediate demand is obtained by the linear technological relation:

$$d_p=Bg \tag{2}$$

where B is the matrix of direct input coefficients b_{ij} that give the direct input requirements of commodity i for each unit of output from industry j. Variable g represents the vector of gross industry output.

The supply of commodities may come from business sector current production q, from imports for domestic purposes m_D, from imports for re-export purposes m_R, from the government sector a, from the withdrawals from inventories v, or from other leakages from the business sector s_c or s_o:

$$o_t=q+m_D+m_R+a+v+s_c+s_o \tag{3}$$

All non-business supply components are related to demand components via simple linear relationships. First, there is a trivial relationship between re-exports and imports for re-exports purposes:

$$m_R = x_R^* \tag{4}$$

We may notice that re-exports have no effect on output as these are completely satisfied by imports. We can thus ignore m_R and x_R^* in the specification of the model. Other non-business supply are endogenous and obtained by the following simple "behavioural" relations:

$$m_D = \hat{\mu}_c e_c + \hat{\mu}_{\bar{e}} \bar{e} + \hat{\mu}_I Bg \tag{5}$$

$$a = \hat{\alpha}_c e_c + \hat{\alpha}_{\bar{e}} \bar{e} + \hat{\alpha}_x x_D^* + \hat{\alpha}_I Bg \tag{6}$$

$$v = \hat{\beta}_c e_c + \hat{\beta}_{\bar{e}} \bar{e} + \hat{\beta}_x x_D^* + \hat{\beta}_I Bg \tag{7}$$

$$s_c = \hat{\nu} e_c \tag{8}$$

$$s_o = \hat{\gamma}_c e_c + \hat{\gamma}_{\bar{e}} \bar{e} + \hat{\gamma}_x x_D^* + \hat{\gamma}_I Bg \tag{9}$$

The last set of model parameters, the domestic market share matrix, assigns to every business industry its share of production of every commodity supplied by the business sector:

$$g = Dq \tag{10}$$

where D has as many rows as there are industries in the model and as many columns as there are commodities. By construction, the sum of all the industry shares of a particular commodity are equal to 1, except for non-competitive imports like tropical fruits in which case all shares are zero.

We need one last relationship to solve the model, the equilibrium condition:

$$o_t = d_t \tag{11}$$

The Reduced-Form Output Determination Model

For the previous model, we can obtain the reduced form of any of the endogenous variables: $d_t, d_p, o_t, q, m_D, a, v, s_c, s_o$ or g. Our goal is to set the basis for the growth decomposition model for output, so we need only to express the reduced form for gross industry output by substituting (1) to (10) into (11) and solve for g:

$$g = [I - D(I - \hat{\mu}_I - \hat{\alpha}_I - \hat{\beta}_I - \hat{\gamma}_I)B]^{-1} D[(I - \hat{\nu} - \hat{\mu}_c - \hat{\alpha}_c - \hat{\beta}_c - \hat{\gamma}_c)e_c + (I - \hat{\mu}_{\bar{e}} - \hat{\alpha}_{\bar{e}} - \hat{\beta}_{\bar{e}} - \hat{\gamma}_{\bar{e}})\bar{e} + (I - \hat{\alpha}_x - \hat{\beta}_x - \hat{\gamma}_x)x_D^*] \tag{12}$$

The right-hand side expression contains nothing but exogenous demand e_c, $\bar{e}$ and x_D^* as well as all model parameters. This is the expression for the output determination model often used to analyse the impact on gross output by industry resulting from a change in demand or a change in propensity to import, for example.[19]

The Growth Decomposition Model

The previous output determination model can be evaluated by using data for different periods, and one can thus say from an accounting perspective that the difference in gross output between two periods can be "explained" by the changes in exogenous demand e_c, $\bar{e}$ and x_D^*, and by the model parameters. The growth model is used to analyse the observed change in output per industry g_0 from a reference year to its value g_1 in a comparative year. We can analyse the growth in many different ways. Let us first look at the absolute difference model:

$$\begin{aligned}\Delta g = g_1 - g_0 = {} & A_1^{-1} D_1 [(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1}) e_{c1} + (\hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1}) \bar{e}_1 + (I - \hat{\kappa}_{x1}) x_{D1}^*] \\ & - A_0^{-1} D_0 [(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0}) e_{c0} + (I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}) \bar{e}_0 + (I - \hat{\kappa}_{x0}) x_{D0}^*]\end{aligned} \tag{13}$$

where

$$A = I - D(I - \hat{\mu}_I - \hat{\alpha}_I - \hat{\beta}_I - \hat{\gamma}_I)B$$

$$\hat{\kappa}_c = \hat{\nu} + \hat{\alpha}_c + \hat{\beta}_c + \hat{\gamma}_c$$

$$\hat{\kappa}_{\bar{e}} = \hat{\alpha}_{\bar{e}} + \hat{\beta}_{\bar{e}} + \hat{\gamma}_{\bar{e}}$$

$$\hat{\kappa}_x = \hat{\alpha}_x + \hat{\beta}_x + \hat{\gamma}_x$$

For the analysis, we group the terms on the right-hand side in order to isolate various "sources" of change in gross output. In the discrete mode, there is no unique way to write the decomposition. The following derivation shows how to arrive at the decomposition with base-year coefficients and comparative-year weights. Table E-1 presents the expressions for both decompositions of the absolute-difference model (13). The second decomposition uses comparative-year coefficients and base-year weights. All reported calculations for the absolute-difference model and for other indicators derived from the growth decomposition model are arithmetic averages of both decompositions. Let

$$H = (I - \hat{\mu}_c - \hat{\kappa}_c) e_c + (I - \hat{\mu}_{\bar{e}} - \hat{\kappa}_{\bar{e}}) \bar{e} + (I - \hat{\kappa}_x) x_D^* \tag{14}$$

We can therefore write (13) as:

$$\Delta g = A_1^{-1} D_1 H_1 - A_0^{-1} D_0 H_0 \tag{15}$$

We can decompose Δg using two different approaches:

$$\Delta g = A_1^{-1} D_1 H_1 - A_0^{-1} D_0 H_0 + A_0^{-1} D_1 H_1 - A_0^{-1} D_1 H_1 \tag{16}$$

or

$$\Delta g = A_1^{-1} D_1 H_1 - A_0^{-1} D_0 H_0 + A_1^{-1} D_0 H_0 - A_1^{-1} D_0 H_0 \tag{17}$$

Table D-1
Decompositions of the Absolute Difference of Gross Output, by Industry Δg

Sources of Change	Base-Year Coefficients, Comparative-Year Weights	Comparative-Year Coefficients, Base-Year Weights
Changes in:		
Personal Consumption	$A_0^{-1}D_0(I-\hat{\mu}_{c0}-\hat{\kappa}_{c0})\Delta e_c$	$A_1^{-1}D_1(I-\hat{\mu}_{c1}-\hat{\kappa}_{c1})\Delta e_c$
Investment	$A_0^{-1}D_0(I-\hat{\mu}_{\bar{e}0}-\hat{\kappa}_{\bar{e}0})\Delta e_I$	$A_1^{-1}D_1(I-\hat{\mu}_{\bar{e}1}-\hat{\kappa}_{\bar{e}1})\Delta e_I$
Government Expenditures	$A_0^{-1}D_0(I-\hat{\mu}_{\bar{e}0}-\hat{\kappa}_{\bar{e}0})\Delta e_G$	$A_1^{-1}D_1(I-\hat{\mu}_{\bar{e}1}-\hat{\kappa}_{\bar{e}1})\Delta e_G$
Exports	$A_0^{-1}D_0(I-\hat{\kappa}_{x0})\Delta x_D^*$	$A_1^{-1}D_1(I-\hat{\kappa}_{x1})\Delta x_D^*$
Import Substitution of Final Goods	$-A_0^{-1}D_0[\Delta\hat{\mu}_{e_c}e_{c1}+\Delta\hat{\mu}_{\bar{e}}\bar{e}_1]$	$-A_1^{-1}D_1[\Delta\hat{\mu}_{e_c}e_{c0}+\Delta\hat{\mu}_{\bar{e}}(e_{I0}+e_{G0})]$
Import Substitution of Intermediate Goods	$-A_0^{-1}D_0\Delta\hat{\mu}_I B_1 g_1$	$-A_1^{-1}D_1\Delta\hat{\mu}_I B_0 g_0$
Direct Input Coefficients	$A_0^{-1}D_0(I-\hat{\mu}_{I0}-\hat{\kappa}_{I0})\Delta B g_1$	$A_1^{-1}D_1(I-\hat{\mu}_{I1}-\hat{\kappa}_{I1})\Delta B g_0$
Market shares	$A_0^{-1}\Delta D[(I-\hat{\mu}_{e_c1}-\hat{\kappa}_{e_c1})e_{c1}+(I-\hat{\mu}_{\bar{e}1}-\hat{\kappa}_{\bar{e}1})\bar{e}_1 +(I-\hat{\kappa}_{x1})x_{D1}^*+(I-\hat{\mu}_{I1}-\hat{\kappa}_{I1})B_1 g_1]$	$A_1^{-1}\Delta D[(I-\hat{\mu}_{e_c0}-\hat{\kappa}_{e_c0})e_{c0}+(I-\hat{\mu}_{\bar{e}0}-\hat{\kappa}_{\bar{e}0})\bar{e}_0 +(I-\hat{\kappa}_{x0})x_{D0}^*+(I-\hat{\mu}_{I0}-\hat{\kappa}_{I0})B_0 g_0]$
Other Leakages from the Substitution of Final Demand and Intermediate Goods	$-A_0^{-1}D_0[\Delta\hat{\kappa}_{e_c}e_{c1}+\Delta\hat{\kappa}_{\bar{e}}\bar{e}_1+\Delta\hat{\kappa}_x x_{D1}^*+\Delta\hat{\kappa}_I B_1 g_1]$	$-A_1^{-1}D_1[\Delta\hat{\kappa}_{e_c}e_{c0}+\Delta\hat{\kappa}_{\bar{e}}\bar{e}_0+\Delta\hat{\kappa}_x x_{D0}^*+\Delta\hat{\kappa}_I B_0 g_0]$

The above two expressions for Δg lead to the two decompositions presented in Table D-1. We go through the derivation of the first one as follows. First, we can write (16) the following way:

$$\begin{aligned}\Delta g &= A_1^{-1}D_1H_1 - A_0^{-1}[D_1H_1 - (D_1H_1 - D_0H_0)] \\ &= A_1^{-1}D_1H_1 - A_0^{-1}[D_1H_1 - \Delta(DH)] \\ &= A_0^{-1}\Delta(DH) + (A_1^{-1} - A_0^{-1})D_1H_1\end{aligned} \tag{18}$$

We develop new expressions for $\Delta(DH)$ and for $(A_1^{-1} - A_0^{-1})D_1H_1$, which we will substitute back into (18).

We can write $\Delta(DH)$ as:

$$\begin{aligned}\Delta(DH) = {} & D_1(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} + D_1(I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 + D_1(I - \hat{\kappa}_{x1})x_{D1}^* \\ & - D_0(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})e_{c0} - D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\bar{e}_0 - D_0(I - \hat{\kappa}_{x0})x_{D0}^*\end{aligned} \tag{19}$$

and expand it as:

$$\begin{aligned}\Delta(DH) = {} & D_1(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} + D_1(I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 + D_1(I - \hat{\kappa}_{x1})x_{D1}^* \\ & - D_0(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})e_{c0} - D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\bar{e}_0 - D_0(I - \hat{\kappa}_{x0})x_{D0}^* \\ & + D_0(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} - D_0(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} + D_0(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})e_{c1} \\ & - D_0(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})e_{c1} + D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 - D_0(I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 \\ & + D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\bar{e}_1 - D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\bar{e}_1 + D_0(I - \hat{\kappa}_{x1})x_{D1}^* - D_0(I - \hat{\kappa}_{x1})x_{D1}^* \\ & + D_0(I - \hat{\kappa}_{x0})x_{D1}^* - D_0(I - \hat{\kappa}_{x0})x_{D1}^*\end{aligned} \tag{20}$$

We can now group the terms as follows:

$$\begin{aligned}\Delta(DH) = {} & D_0(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})\Delta e + D_0\Delta(I - \hat{\mu}_c - \hat{\kappa}_c)e_{c1} + \Delta D(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} \\ & + D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\Delta\bar{e} + D_0\Delta(I - \hat{\mu}_{\bar{e}})\bar{e}_1 + \Delta D(I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 \\ & + D_0(I - \hat{\kappa}_{x0})\Delta x_D^* + D_0\Delta(I - \hat{\kappa}_x)x_{D1}^* + \Delta D(I - \hat{\kappa}_{x1})x_{D1}^*\end{aligned} \tag{21}$$

We can write $(A_1^{-1} - A_0^{-1})D_1H_1$ as:

$$\begin{aligned}(A_1^{-1} - A_0^{-1})D_1H_1 &= -(A_1^{-1} - A_0^{-1})D_1H_1 \\ &= A_0^{-1}(A_0 - A_1)A_1^{-1}D_1H_1 \\ &= A_0^{-1}(A_0 - A_1)g_1\end{aligned} \tag{22}$$

We can write $A_0 - A_1$ as:

$$A_0 - A_1 = I - D_0(I - \hat{\mu}_{I0} - \hat{\kappa}_{I0})B_0 - [I - D_1(I - \hat{\mu}_{I1} - \hat{\kappa}_{I1})B_1] \tag{23}$$

where $\hat{\kappa}_I = \hat{\alpha}_I + \hat{\beta}_I + \hat{\gamma}_I$

We can expand (23) as follows:

$$\begin{aligned} A_0-A_1 &= D_1(I-\hat{\mu}_{11}-\hat{\kappa}_{11})B_1-D_0(I-\hat{\mu}_{10}-\hat{\kappa}_{10})B_0+D_0(I-\hat{\mu}_{10}-\hat{\kappa}_{10})B_1 \\ &\quad -D_0(I-\hat{\mu}_{10}-\hat{\kappa}_{10})B_1+D_0(I-\hat{\mu}_{11}-\hat{\kappa}_{11})B_1-D_0(I-\hat{\mu}_{11}-\hat{\kappa}_{11})B_1 \\ &= D_0(I-\hat{\mu}_{10}-\hat{\kappa}_{10})\Delta B+D_0\Delta(I-\hat{\mu}_1-\hat{\kappa}_1)B_1+\Delta D(I-\hat{\mu}_{11}-\hat{\kappa}_{11})B_1 \end{aligned} \tag{24}$$

We can now substitute (24) into (22) and the result into (18) and substitute (21) into (18) as well and obtain:

$$\begin{aligned} \Delta g &= A_0^{-1}(I-\hat{\mu}_{c0}-\hat{\kappa}_{c0})\Delta e_c+A_0^{-1}D_0\Delta(I-\hat{\mu}_c-\hat{\kappa}_c)e_{c1}+A_0^{-1}\Delta D(I-\hat{\mu}_{c1}-\hat{\kappa}_{c1})e_c \\ &\quad +A_0^{-1}D_0(I-\hat{\mu}_{\bar{e}0}-\hat{\kappa}_{\bar{e}0})\Delta\bar{e}+A_0^{-1}D_0\Delta(I-\hat{\mu}_{\bar{e}}-\hat{\kappa}_{\bar{e}})e_1+A_0^{-1}\Delta D(I-\hat{\mu}_{\bar{e}1}-\hat{\kappa}_{\bar{e}1})\bar{e}_1 \\ &\quad +A_0^{-1}(I-\hat{\kappa}_{x0})\Delta x_D^*+A_0^{-1}\Delta(I-\hat{\kappa}_x)x_{D1}^*+A_0^{-1}\Delta D(I-\hat{\kappa}_{x1})x_{D1}^* \\ &\quad +A_0^{-1}D_0(I-\hat{\mu}_{10}-\hat{\kappa}_{10})\Delta Bg_1+A_0^{-1}D_0\Delta(I-\hat{\mu}_1-\hat{\kappa}_1)B_1g_1 \\ &\quad +A_0^{-1}\Delta D(I-\hat{\mu}_{11}-\hat{\kappa}_{11})B_1g_1 \end{aligned} \tag{25}$$

We can further isolate the changes in gross output resulting from changes in import substitution μ and changes in other leakages κ. In Table D-1 we have kept as separate terms the changes in the import substitution of intermediate goods and those occurring from the import substitution of final goods. We have also split the sources of growth occurring from the growth in investments e_I and in government expenditures e_G, using the definition:

$$\bar{e}=e_I+e_G \tag{26}$$

The above decomposition leads to alternative indicators directly derived from them. If we divide every term by the absolute change in gross output Δg, we obtain share indicators of output growth from the various sources. If we multiply these share indicators by the average annual output growth rate for every industry, we obtain growth rate indicators. Every term indicates how much it contributed to the growth of each industry. Growth rate indicators have been reported in the study.

The Deviation Model

An alternative model leads to measures to evaluate the relative importance of industries to the overall growth of the economy. The aim of the deviation model is to measure the deviations of output among industries relative to a reference scenario. These deviations themselves are also decomposed to account for their sources. The reference scenario used for the OECD study is that of balanced growth whereby all sectors of the economy grow at the same rate.

We define λ as the ratio of total gross output of the comparative year to the base year:

$$\lambda=\frac{i'g_1}{i'g_0} \quad \text{where } i \text{ is a summation vector.} \tag{27}$$

Table D-2
Decompositions of the Deviations of Output Relative to Balanced Growth Output

Sources of Change	Base-Year Coefficients, Comparative-Year Weights	Comparative-Year Coefficients, Base-Year Weights
Changes in:		
Personal Consumption	$A_0^{-1}D_0(I-\hat{\mu}_{c0}-\hat{\kappa}_{c0})\delta e_c$	$A_1^{-1}D_1(I-\hat{\mu}_{c1}-\hat{\kappa}_{c1})\delta e_c$
Investment	$A_0^{-1}D_0(I-\hat{\mu}_{\bar{e}0}-\hat{\kappa}_{\bar{e}0})\delta e_I$	$A_1^{-1}D_1(I-\hat{\mu}_{\bar{e}1}-\hat{\kappa}_{\bar{e}1})\delta e_I$
Government Expenditures	$A_0^{-1}D_0(I-\hat{\mu}_{\bar{e}0}-\hat{\kappa}_{\bar{e}0})\delta e_G$	$A_1^{-1}D_1(I-\hat{\mu}_{\bar{e}1}-\hat{\kappa}_{\bar{e}1})\delta e_G$
Exports	$A_0^{-1}D_0(I-\hat{\kappa}_{x0})\delta x_D^*$	$A_1^{-1}D_1(I-\hat{\kappa}_{x1})\delta x_D^*$
Import Substitution of Final Goods	$-A_0^{-1}D_0(\Delta\hat{\mu}_{e_c}e_{c1}+\Delta\hat{\mu}_{\bar{e}}\bar{e}_1)$	$-A_1^{-1}D_1(\Delta\hat{\mu}_{e_c}\lambda e_{c0}+\Delta\hat{\mu}_{\bar{e}}\lambda\bar{e}_0)$
Import Substitution of Intermediate Goods	$-A_0^{-1}D_0\Delta\hat{\mu}_I B_1 g_1$	$-A_1^{-1}D_1\Delta\hat{\mu}_I B_0\lambda g_0$
Direct Input Coefficients	$A_0^{-1}D_0(I-\hat{\mu}_{I0}-\hat{\kappa}_{I0})\Delta B g_1$	$A_1^{-1}D_1(I-\hat{\mu}_{I1}-\hat{\kappa}_{I1})\Delta B\lambda g_0$
Market Shares	$A_0^{-1}\Delta D[(I-\hat{\mu}_{e_c1}-\hat{\kappa}_{e_c1})e_{c1}+(I-\hat{\mu}_{\bar{e}1}-\hat{\kappa}_{\bar{e}1})\bar{e}_1 +(I-\hat{\kappa}_{x1})x_{D1}^*+(I-\hat{\mu}_{I1}-\hat{\kappa}_{I1})B_1 g_1]$	$A_1^{-1}\Delta D[(I-\hat{\mu}_{e_c0}-\hat{\kappa}_{e_c0})e_{c0}+(I-\hat{\mu}_{\bar{e}0}-\hat{\kappa}_{\bar{e}0})\lambda\bar{e}_0 +(I-\hat{\kappa}_{x0})\lambda x_{D0}^*+(I-\hat{\mu}_{I0}-\hat{\kappa}_{I0})B_0\lambda g_0]$
Other Leakages from the Substitution of Final Demand and Intermediate Goods	$-A_0^{-1}D_0[\Delta\hat{\kappa}_{e_c}e_{c1}+\Delta\hat{\kappa}_{\bar{e}}\bar{e}_1+\Delta\hat{\kappa}_x x_{D1}^*+\Delta\hat{\kappa}_I B_1 g_1]$	$-A_1^{-1}D_1[\Delta\hat{\kappa}_{e_c}e_{c0}+\Delta\hat{\kappa}_{\bar{e}}\bar{e}_0+\Delta\hat{\kappa}_x x_{D0}^*+\Delta\hat{\kappa}_I B_0\lambda g_0]$

We can then measure the deviation of gross output as follows:

$$\delta g = g_1 - \lambda g_0 \tag{28}$$

In the reference scenario, we apply the scalar λ reflecting the trend in gross output growth to the final demand in order to calculate the decomposition; given the linearity of the model, we have:

$$\lambda g_0 = \hat{\eta}_0 A_0^{-1} D[(I-\hat{\mu}_{c0}-\hat{\kappa}_{c0})\lambda e_{c0}+(I-\hat{\mu}_{\bar{e}0}-\hat{\kappa}_{\bar{e}0})\lambda \bar{e}_0+(I-\hat{\kappa}_{x0})\lambda x^*_{D0}] \tag{29}$$

We can thus write the expression for the deviation of gross output:

$$\begin{aligned}\delta g = {} & \hat{\eta}_1 A_1^{-1} D[(I-\hat{\mu}_{c1}-\hat{\kappa}_{c1})e_{c1}+(I-\hat{\mu}_{\bar{e}1}-\hat{\kappa}_{\bar{e}1})\bar{e}_1+(I-\hat{\kappa}_{x1})x^*_{D1}] \\ & -\hat{\eta}_0 A_0^{-1} D[(I-\hat{\mu}_{c0}-\hat{\kappa}_{c0})\lambda e_{c0}+(I-\hat{\mu}_{\bar{e}0}-\hat{\kappa}_{\bar{e}0})\lambda \bar{e}_0+(I-\hat{\kappa}_{x0})\lambda x^*_{D0}]\end{aligned} \tag{30}$$

By analogy with the absolute difference growth decomposition model we can calculate two decompositions with comparative-year coefficients and base-year weights, and *vice versa*. Both decompositions are reported in Table D-2. Again, all reported calculations are based on the arithmetic averages of both measures.

The measures reported from the deviation model are not the deviations from the reference scenario *per se* but rather the relative-share indicators that take into account the importance of the growth of each industry within the economy:

$$\begin{aligned}\Delta h &= \frac{g_1}{i'g_i} - \frac{g_0}{i'g_0} \\ &= \frac{g_1}{i'g_1} - \frac{\lambda g_0}{i'g_1} + \frac{\lambda g_0}{i'g_1} - \frac{g_0}{i'g_0} \\ &= \frac{\delta g}{i'g_1}\end{aligned} \tag{31}$$

We can thus divide the deviations obtained from (30) to decompose the relative share indicators by dividing every term by the scalar $i'g_1$.

ENDNOTES

1 See for example, Industry Canada (1994).

2 The data was obtained from the productivity database of the input/output model. Four industries were excluded: postal services, other utilities (not elsewhere classified), government royalties on natural resources, and owner-occupied dwellings. The Canadian input/output tables also contain data on seven "fictive" industries and an equal number of fictive commodities. The "fictive industry" technique is used for routing groups of commodities as inputs into industries when the precise commodity content is unknown. To avoid multiple-counting over and above the double-counting already present in the concept of gross output, we have not considered these industries in the growth trend used in the third measure, nor have we reported them separately, since they are of no interest in their own.

3 The Lilien index is calculated as follows:

$$\sigma_t = \left[\sum_{i=1}^{N} l_{it}/L_t \{ \log (l_{it}/l_{it-1}) - \log (L_t/L_{t-1}) \}^2 \right]^{1/2}$$

and the dissimilarity index, as follows:

$$\left[0.5 \times \sum_{i=1}^{N} \left| (l_{it}/L_t) - (l_{it-1}/L_{t-1}) \right| \right]$$

4 The main theme found in the recent literature on endogenous growth theory is that the source of long-run economic growth is the accumulation of knowledge. The major characteristics of this theory, as compared to the standard theory, are a departure from the assumption of diminishing returns and an explicit recognition of the role of technological change. The new growth theories provide several sources for increasing returns, including: a) knowledge, derived through the accumulated investment in physical capital, which augments the labour force; b) an R&D sector that produces "productivity enhancing" ideas, leading to technical change; c) the accumulation of human capital through education and experience; and d) innovation that recognizes obsolescence and new goods ("creative destruction"). See for example, Romer (1986, 1990) and Grossman & Helpman (1991). For empirical evidence, see Delong & Summers (1991) and Mankiw, Romer & Weil (1992).

5 Workers with trade or vocational education, postsecondary non-university education, and university education.

6 Knowledge workers include those with occupations in the natural sciences, engineering, and mathematics; and in education and related occupations; as well as other managers and administrators; people in positions related to management and administration; and people in the social sciences, in law and jurisprudence, in medicine and health, and in writing.

7 This includes those with occupations in the natural sciences, engineering, and mathematics.

8 Lee & Has (1996) argue that while their approach focuses on knowledge-producing rather than knowledge-using industries, it invariably picks up some knowledge-using industries since the human capital content of an industry is also used for the purposes of classification.

9 Lee & Has (1996) note that all three indicators of R&D activity by industry are highly correlated. R&D intensity is highly correlated with R&D personnel per worker (rank correlation coefficient of 0.94) and professional R&D personnel (0.95). Moreover, the rank correlation coefficient between the proportion of workers with postsecondary education and the proportion of knowledge workers is relatively high (0.85), suggesting that there is a rather close match between the level of education and knowledge-intensive occupations. However, the rank correlation coefficient between the proportion of scientists, engineers, and technicians and the proportion of knowledge workers is low (0.61). This suggests that this occupational category tends to focus on the scientific or technological capacity of an industry and that it may not, therefore, be particularly adequate to measure the knowledge content of service industries that are not involved in producing new processes or products. For further details, see Lee & Has (1996).

10 In a previous draft of this paper (Gera & Mang, 1995), the Department of Finance methodology was used to classify industries on the basis of knowledge intensity. The results obtained with that approach reveal that the high-knowledge sector consistently displayed above-average growth.

11 Although widely used, this classification scheme suffers from major drawbacks; see for example, Wong (1990), OECD (1992) and Beloskie (1992). In Appendix Table B-1, this classification criterion is spelled out and industries are grouped accordingly.

12 Detailed industry tables and breakdowns are available from the authors upon request.

13 For Canadian evidence on inter-industry wage differentials, see Gera & Grenier (1994).

14 Baldwin & Rafiquzzaman (1994) argue that for the resource-based sector, the primary factor affecting competition is access to abundant natural resources; for the labour-intensive sector, it is labour costs; for scale-based industries, it is the length of production runs; for differentiated goods, it is the tailoring of production to highly varied demand characteristics; and for science-based industries, it is the rapid application of scientific advancements.

15 For evidence on industrial restructuring during the recessions of the early 1980s and 1990s, see Gera *et al.* (1993).

16 Detailed industry results are available from the authors upon request. Results for the sources of output growth in 111 industries are presented in Appendix C.

17 Poole (1993); Mercier, Durand & Diaz (1991); Statistics Canada (1987); Statistics Canada (1991).

18 We follow the notation used in Mercier *et al.* (1991)..

19 In the standard model, the parameters are estimated using the current dollar tables as opposed to the constant dollar tables as in the present model.

BIBLIOGRAPHY

Baldwin, J. and M. Rafiquzzaman (1994). "Structural change in the Canadian manufacturing sector (1970-1990)." Research Paper Series 61. Ottawa. Statistics Canada.

Beck, N. (1992). *Shifting Gears: Thriving in the New Economy*. Toronto. Harper Collins Publishers Ltd.

Beloskie, C. (1992). "Output and employment in high-tech industries." *Canadian Economic Observer*. September.

Cox, D. and R. G. Harris (1991). *International Trade and the Service Sector in the Canadian Economy: An Input-Output Analysis*. Vancouver. Fraser Institute.

Delong, J. B. and L. H. Summers (1991). "Equipment investment and economic growth." *Quarterly Journal of Economics*, 106(May): 445-502.

Department of Finance (1992). "Employment growth in high-tech and knowledge industries." Ottawa. Mimeo.

Drucker, P. (1993). *Post-Capitalist Society*. New York. Harper Collins.

Economic Council of Canada (1990). *Good Jobs, bad Jobs: Employment in the Service Economy*. Ottawa. Supply and Services Canada.

Gera, S. and G. Grenier (1994). "Interindustry wage differentials and efficiency wages: some Canadian evidence." *Canadian Journal of Economics,* February: 1.

Gera, S. and K. Mang (1995). "Changing industrial structure: shifts in output growth." Paper read at the Canadian Economic Association Meetings. Montreal, 31 May-2 June.

Gera, S., D. Caldwell, and D. Ferguson (1993). "Industrial restructuring in Canadian manufacturing: a comparison between the early 1980s and 1990s." Paper read at to the CERF/Statistics Canada Joint Conference. Ottawa, 5 March.

Grossman, G. M. and E. Helpman (1991). "Quality ladders in the theory of growth." *Review of Economic Studies*, 58: 43-61.

Harris, R. (1993). "Trade, money, and wealth in the Canadian economy." Toronto. C.D. Howe Institute Benefactors Lecture.

Industry Canada (1994). *Building a More Innovative Economy*. Ottawa.

Katz, L. F. and L. H. Summers (1989). "Industry rents: evidence and implications." *Brookings Papers: Microeconomics*, 209-90.

Krugman, P. R. (1991). "Technology and international competition: overview." Document prepared for a National Academy of Engineering symposium on Linking Trade and Technology Policies: An International Comparison, National Academy of Sciences. Washington, 10-11 June.

Layard, R. S., S. Nickell, and R. Jackman (1991). *Unemployment: Macroeconomic Performance and the Labour Market*. Toronto. Oxford University Press.

Lee, F. and H. Has (1996). "A quantitative assessment of high-knowledge industries versus low-knowledge industries." In P. Howitt (ed.). *The Implications of Knowledge-Based Growth for Micro-Economic Policies*. The Industry Canada Research Series. Calgary. The University of Calgary Press.

Lilien, D. M. (1982). "Sectoral shifts and cyclical unemployment." *Journal of Political Economy*, 90(August): 777-93.

Mankiw, N. G., D. Romer, and D. N. Weil (1992). "A contribution to the empirics of economic growth." *Quarterly Journal of Economics,* 102: 407-37.

Mercier, P., R. Durand, and A. Diaz (1991). "Specification of parameters for the national input-output model." Technical Series 18(E). Ottawa. Statistics Canada Input-Output Division.

Organisation for Economic Co-operation and Development (1987). *Structural Adjustment and Economic Performance*. Paris.

_____(1992). *Structural Change and Industrial Performance: A Seven Country Growth Decomposition Study*. Paris.

_____(1994). *Jobs Study: Evidence and Explanations. Labour Market Trends and Underlying Forces of Change*. Paris.

_____(1996). *Technology, Productivity and Job Creation*. Paris.

Papaconstantinou, G. (1995). "Employment performance in the industry of OECD countries: trends and underlying factors." Paper read at the Expert Workshop on Technology, Productivity and Employment: Macroeconomic and Sectoral Evidence. Paris, 19-20 June.

Poole, E. (1993). "A guide to using the input-output model of Statistics Canada." Technical Series 58-E. Ottawa. Statistics Canada Input-Output Division.

Romer, P. M. (1986). "Increasing returns and long-run growth." *Journal of Political Economy*, 94(October).

_____(1990). "Endogenous technological change." *Journal of Political Economy,* 98.

Sakurai, N. (1995). "Structural change and employment: empirical evidence for eight OECD countries." *STI Review,* 15.

Statistics Canada (1987). *The Input-Output Structure of the Canadian Economy 1961-81.* Cat. 15-510. Ottawa. 37-39.

_____(1991). "Statistics Canada's input-output model: general description, critical analysis of partially closed version and alternative solutions." Technical Series 52-E. Ottawa. Statistics Canada Input-Output Division.

Tyson, L. (1992). *Who's Bashing Whom: Trade Conflict in High-Technology Industries.* Washington (D.C.). Institute for International Economics.

Wong, F. (1990). "High technology at work." *Perspectives*, Spring: 17-28.

INDUSTRY CANADA RESEARCH PUBLICATIONS

INDUSTRY CANADA WORKING PAPER SERIES

No. 1 **Economic Integration in North America: Trends in Foreign Direct Investment and the Top 1,000 Firms**, Industry Canada, Micro-Economic Policy Analysis Staff including John Knubley, Marc Legault and P. Someshwar Rao, 1994.

No. 2 **Canadian-Based Multinationals: An Analysis of Activities and Performance**, Industry Canada, Micro-Economic Policy Analysis Staff including P. Someshwar Rao, Marc Legault and Ashfaq Ahmad, 1994.

No. 3 **International R&D Spillovers Between Industries in Canada and the United States**, Jeffrey I. Bernstein, Carleton University and the National Bureau of Economic Research, under contract with Industry Canada, 1994.

No. 4 **The Economic Impact of Mergers and Acquisitions on Corporations**, Gilles Mcdougall, Micro-Economic Policy Analysis, Industry Canada, 1995.

No. 5 **Steppin' Out: An Analysis of Recent Graduates Into the Labour Market**, Ross Finnie, School of Public Administration, Carleton University and Statistics Canada, 1995.

No. 6 **Measuring the Compliance Cost of Tax Expenditures: The Case of Research and Development Incentives**, Sally Gunz, University of Waterloo, Alan Macnaughton, University of Waterloo, and Karen Wensley, Ernst & Young, Toronto, under contract with Industry Canada, 1996.

No. 7 **Governance Structure, Corporate Decision-Making and Firm Performance in North America**, P. Someshwar Rao and Clifton R. Lee-Sing, Micro-Economic Policy Analysis, Industry Canada, 1996.

No. 8 **Foreign Direct Investment and APEC Economic Integration**, Ashfaq Ahmad, P. Someshwar Rao and Colleen Barnes, Micro-Economic Policy Analysis, Industry Canada, 1996.

No. 9 **World Mandate Strategies for Canadian Subsidiaries**, Julian Birkinshaw, Institute of International Business, Stockholm School of Economics, under contract with Industry Canada, 1996.

No. 10 **R&D Productivity Growth in Canadian Communications Equipment and Manufacturing**, Jeffrey I. Bernstein, Carleton University and The National Bureau of Economic Research, under contract with Industry Canada, 1996.

No. 11 **Long-run Perspective on Canadian Regional Convergence**, Serge Coulombe, Department of Economics, University of Ottawa, and Frank C. Lee, Industry Canada, 1996.

No. 12 **Implications of Technology and Imports on Employment and Wages in Canada**, Frank C. Lee, Industry Canada, 1996.

No. 13 **The Development of Strategic Alliances in Canadian Industries: A Micro Analysis,** Sunder Magun, Applied International Economics, 1996.

No. 14 **Employment Performance in the Knowledge-Based Economy**, Surendra Gera, Industry Canada, and Philippe Massé, Human Resources Development Canada, 1996.

No. 15 **The Knowledge-Based Economy: Shifts in Industrial Output**, Surendra Gera, Industry Canada, and Kurt Mang, Department of Finance, 1997.

INDUSTRY CANADA DISCUSSION PAPER SERIES

No. 1 **Multinationals as Agents of Change: Setting a New Canadian Policy on Foreign Direct Investment**, Lorraine Eden, Carleton University, 1994.

No. 2 **Technological Change and International Economic Institutions**, Sylvia Ostry, Centre for International Studies, University of Toronto, under contract with Industry Canada, 1995.

No. 3 **Canadian Corporate Governance: Policy Options**, Ronald. J. Daniels, Faculty of Law, University of Toronto, and Randall Morck, Faculty of Business, University of Alberta, 1996.

No. 4 **Foreign Direct Investment and Market Framework Policies: Reducing Frictions in APEC Policies on Competition and Intellectual Property**, Ron Hirshhorn, 1996.

INDUSTRY CANADA OCCASIONAL PAPER SERIES

No. 1 **Formal and Informal Investment Barriers in the G-7 Countries: The Country Chapters**, Industry Canada, Micro-Economic Policy Analysis Staff including Ashfaq Ahmad, Colleen Barnes, John Knubley, Rosemary D. MacDonald and Christopher Wilkie, 1994.

Formal and Informal Investment Barriers in the G-7 Countries: Summary and Conclusions, Industry Canada, Micro-Economic Policy Analysis Staff including Ashfaq Ahmad, Colleen Barnes and John Knubley, 1994.

No. 2 **Business Development Initiatives of Multinational Subsidiaries in Canada**, Julian Birkinshaw, University of Western Ontario, under contract with Industry Canada, 1995.

No. 3 **The Role of R&D Consortia in Technology Development**, Vinod Kumar, Research Centre for Technology Management, Carleton University, and Sunder Magun, Centre for Trade Policy and Law, University of Ottawa and Carleton University, under contract with Industry Canada, 1995.

No. 4 **Gender Tracking in University Programs**, Sid Gilbert, University of Guelph, and Alan Pomfret, King's College, University of Western Ontario, 1995.

No. 5 **Competitiveness: Concepts and Measures**, Donald G. McFetridge, Department of Economics, Carleton University, 1995.

No. 6 **Institutional Aspects of R&D Tax Incentives: The SR&ED Tax Credit**, G. Bruce Doern, School of Public Administration, Carleton University, 1995.

No. 7 **Competition Policy as a Dimension of Economic Policy: A Comparative Perspective**, Robert D. Anderson and S. Dev Khosla, Economics and International Affairs Branch, Bureau of Competition Policy, Industry Canada, 1995.

No. 8 **Mechanisms and Practices for the Assessment of The Social and Cultural Implications of Science and Technology**, Liora Salter, Osgoode Hall Law School, University of Toronto, under contract with Industry Canada, 1995.

No. 9 **Science and Technology: Perspectives for Public Policy**, Donald G. McFetridge, Department of Economics, Carleton University, under contract with Industry Canada, 1995.

No. 10 **Endogenous Innovation and Growth: Implications for Canada**, Pierre Fortin, Université du Québec à Montréal and the Canadian Institute for Advanced Research, and Elhanan Helpman, Tel Aviv University and the Canadian Institute for Advanced Research, under contract with Industry Canada, 1995.

No. 11 **The University-Industry Relationship in Science and Technology**, Jérôme Doutriaux, University of Ottawa, and Margaret Barker, Meg Barker Consulting, under contract with Industry Canada, 1995.

No. 12 **Technology and the Economy: A Review of Some Critical Relationships**, Michael Gibbons, University of Sussex, under contract with Industry Canada, 1995.

No. 13 **Management Skills Development in Canada**, Keith Newton, Industry Canada, 1995.

No. 14 **The Human Factor in Firm's Performance: Management Strategies for Productivity and Competitiveness in the Knowledge-Based Economy**, Keith Newton, Industry Canada, 1996.

JOINT PUBLICATIONS

Capital Budgeting in the Public Sector, in collaboration with the John Deutsch Institute, Jack Mintz and Ross S. Preston eds., 1994.

Infrastructure and Competitiveness, in collaboration with the John Deutsch Institute, Jack Mintz and Ross S. Preston eds., 1994.

Getting the Green Light: Environmental Regulation and Investment in Canada, in collaboration with the C.D. Howe Institute, Jamie Benidickson, G. Bruce Doern and Nancy Olewiler, 1994.

To obtain copies of documents published under the *RESEARCH PUBLICATIONS PROGRAM*, please contact:

Publications Officer
Micro-Economic Policy Analysis
Industry Canada
5th Floor, West Tower
235 Queen Street
Ottawa, Ontario, K1A 0H5

Telephone: (613) 952-5704
Fax: (613) 991-1261