WORKING PAPER

EMPLOYMENT PERFORMANCE IN THE KNOWLEDGE-BASED ECONOMY

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EMPLOYMENT PERFORMANCE IN THE KNOWLEDGE-BASED ECONOMY

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EXECUTIVE SUMMARY

There is a growing consensus among academics and policy-makers that most industrialized economies are increasingly becoming "knowledge-based." Knowledge, both as an input and an output, is seen a key source of long-term growth and job creation. Recent evidence shows that the Canadian economy is dynamic and increasingly becoming innovative – i.e., knowledge-based, technology-intensive, and skill-intensive. A major focus of this study is whether structural change towards knowledge-based industries has led to more and better jobs.

The study examines the relationship between structural change and the employment performance of the Canadian economy over the period 1971 to 1991, using Statistics Canada's input/output model. Though largely based on previous work by the OECD (1992), the study employs more timely data and a finer industrial disaggregation (111 industries as opposed to 33), and explores more closely the employment implications of the emergence of the knowledge-based economy. Three policy-related issues are addressed in the paper:

1. Is the employment structure in Canada shifting towards innovative industries – i.e., knowledge-intensive, technology-intensive, science-based, skill-intensive, or high-wage industries?

2. What are the factors driving these shifts? What have been the respective roles of domestic demand, trade, technology, and productivity?

3. How are labour markets adjusting to the new demands of the knowledge-based economy?

Major Findings

- *As in other OECD economies, Canada has seen progressively weaker overall employment growth in recent decades and a relative shift in employment away from the traditional sectors the primary, manufacturing, and construction industries to the service sector.*

  – Annual employment growth in the business sector fell from 3.1 percent in the 1970s to about 1.3 percent between 1986 and 1991. The service sector was the only source of continuous, positive employment growth. In contrast, the relative importance of manufacturing has been severely eroded over the past 20 years.
  – Strong employment growth performances were most evident in industries within the service sector, with the fastest increases taking place in real estate and business services, community and personal services, the hotel and restaurant industry, and the finance and insurance industry. Despite the overall decline in manufacturing employment, four manufacturing industries are in the top 10 fastest growing

industries – computers and office equipment, aircraft manufacturing, rubber and plastics, and pharmaceuticals.

– At the other end of the scale, the adverse effects of structural change have forced severe adjustments in labour-intensive, traditional industries such as textiles, clothing, footwear, and leather. About one quarter of the jobs in shipbuilding were lost.

- *Contrary to popular belief, the pace of structural change in Canada has not been quickening.*

  – The pace of structural change may have accelerated somewhat during the early 1980s, but it has not increased – and if anything, it has decreased – in the late 1980s and early 1990s.

- *Employment growth in Canada is increasingly related to the use and production of knowledge. This transformation has been evident since the early 1970s.*

  – The structure of employment in all sectors is shifting towards knowledge- and technology-intensive industries. In addition, an increasing proportion of employment is accounted for by industries that require workers with more skills and that pay higher wages.
  – In manufacturing, knowledge- and technology-intensive industries experienced the highest employment growth, while low-knowledge and low-technology manufacturing industries have shed jobs. The main source of employment growth remains the service sector, with gains in employment coming from both high- *and* low-knowledge service industries.

- *Although the direction of change has been towards knowledge- and technology-intensive industries, they still account for only a small share of overall employment in Canada.*

  – The majority of jobs are still concentrated in the low- to medium-knowledge and technology-intensive industrial system.
  – In part, this may reflect the fact that the Canadian manufacturing sector is suffering from an "innovation gap" as Canada's high-tech sector has grown at a much slower pace than that of other major industrialized countries over the past 20 years.

- *Employment in high-knowledge industries is less sensitive to cyclical downturns than that in medium- and low-knowledge sectors.*

- *While domestic demand and labour productivity growth have always been important determinants of employment growth, the role played by trade and technology increased during the 1980s and early 1990s*.

- Exports have become a dominant factor in employment growth, particularly in high-knowledge and high-technology manufacturing, and in high-wage industries.
- Conversely, import penetration has adversely affected employment growth in low-knowledge, low-technology, low-wage, low-skill, and labour-intensive manufacturing industries.
- The importance of trade and technology has been increasing in the Canadian service sector, in particular in high- and medium-knowledge services such as business services and the finance, insurance, and real estate group.

• *These demand-driven forces are accompanied by a shift in the structure of labour demand towards skilled workers.*

- Shifts in the occupational structure of employment indicate that the structure of labour demand has shifted in favour of skilled workers in both the manufacturing and service sectors. This phenomenon appears to be widespread, occurring within all industrial sectors, and is not merely the result of employment shifts towards industries that tend to employ more skilled workers.
- The increased demand for high-skilled workers has been reflected in higher relative returns to education and experience (age). In addition, the evidence available on changes in the composition of labour force activity by educational level and by experience indicates that workers with higher skills enjoy higher employment rates and lower unemployment rates.

INTRODUCTION

> "The term "knowledge-based economy" evokes 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 growth is strongly dependent on the production, distribution, and use of knowledge is now being emphasized." (OECD, 1996)

There is a growing consensus among academics and policy-makers that most industrialized economies are increasingly becoming knowledge-based. New growth theories consider that knowledge, both as input and output, is a key source of long-term growth and job creation (Young, 1995; Mankiw, 1995; OECD, 1994; Fortin & Helpman, 1995). This notion also underlies recent approaches to policy-making in Canada (Industry Canada, 1994; Human Resource Development Canada, 1994).

The increased importance of knowledge is evidenced by growing private sector investment in R&D and the rapid emergence of new information and communications technologies (OECD, 1996). Intangible investment is growing much more rapidly than physical investment. Firms and sectors with more knowledge (technology) perform better; countries endowed with more knowledge are more productive and more competitive; and individuals with more knowledge (skills) get better-paid jobs (Guellec, 1995).

Recent evidence shows that the Canadian economy is dynamic and increasingly becoming innovative – i.e., knowledge-, technology-, and skill-intensive. Output in the Canadian manufacturing sector has been shifting out of low-technology, low-skill, low-wage, and labour-intensive industries into high- and medium-technology and high-skill, high-wage industries (Gera and Mang, 1996). While the speed of change in the economy does not appear to be accelerating over time, the factors that contribute to this economic change are shifting in importance. Domestic demand remains an important source of change, but trade and technology played a more important role in the 1980s and early 1990s.

As a result of these developments, some observers have argued that innovation and trade may have led to weaker employment growth in the Canadian economy over the past decade. A major concern in this study, therefore, is the relationship between structural change and employment performance. Has structural change led to more jobs and to better jobs?

In a recent study, the OECD concluded that "international differences in the pattern of employment and unemployment depend to a significant extent on the capacity of national economies to innovate and to absorb new technology through structural change" (OECD, 1996). At the same time, there are growing concerns over how technology and trade affect the demand for workers with different skills and how they affect wages.

Recent studies based on firm-level data find that innovative firms drive structural change towards higher value-added activities. Innovative firms employ more workers, demand higher skills, and pay higher wages (Erlich, 1996; Baldwin, Diverty & Sabourin, 1995). However, while firm-level evidence provides useful insights, it says little about the effects of innovation on employment in a particular sector or an individual industry. Innovative firms may be creating more jobs, but if an industry is largely composed of non-innovators, its employment will fall. In addition, the impact on labour demand in an industry depends on what happens in other industries and in other countries (OECD, 1996).

Against this background, the study addresses three main issues:

- Is the employment structure in Canada shifting towards innovative industries (as defined above)?
- What factors are driving these shifts? What have been the respective roles of domestic demand, trade, technology, and labour productivity?
- How are labour markets adjusting to the new demands of the knowledge-based economy?

Employment growth rates in an industry are directly determined by the growth rates of output and labour productivity. These are, in turn, determined by industry dynamics and, in particular, by competitive intensity, innovation, and trade performance. Here, we adopt a methodology that breaks down changes in employment into factors such as the expansion of domestic demand and of exports, the impact of import penetration, as well as labour productivity growth and changes in production techniques (loosely interpreted as technology).

The study examines, from a micro perspective, changes in the structure of employment in Canada over the period 1971-91. Statistics Canada's input/output (I/O) model of the business sector is used to analyze 111 industries. This approach is similar to that adopted in previous studies (e.g., OECD, 1992; Betts & McCurdy, 1993; Sakurai, 1995), but it employs more timely data and a finer industrial disaggregation; more importantly, it explores the role of knowledge-based industries in the changing structure of employment.

The first chapter briefly presents evidence on the large structural shifts that have occurred in employment at a broad sectoral level and within sectors at quite micro levels. In chapter 2, we ask whether the employment structure in Canada is shifting towards knowledge-based industries. To answer that question, we examine the key characteristics of employment-gaining industries and provide evidence on whether these industries are knowledge-driven – i.e., technology-intensive, high-skill, or high-wage. Chapter 3 examines the demand-side factors that are driving the shifts in employment. In chapter 4, we examine how labour markets are adjusting to these demand-driven shifts, and in particular, how they are reflected in changes in the demand for labour with different skills. Finally, chapter 5 provides the main findings and conclusions.

1. STRUCTURAL SHIFTS IN EMPLOYMENT

In this chapter, we review the long-term trends and shifts in employment in the Canadian economy. We examine the broad sectoral employment shifts that have characterized the Canadian business sector since 1971 and identify which industries have expanded employment and which have shed jobs.

Broad Sectoral Shifts

As have other OECD economies, Canada has seen progressively weaker overall employment growth in recent decades and a relative shift in employment away from the traditional sectors – the primary, manufacturing, and construction industries – towards the service sector (Table 1-1).

Annual employment growth in the business sector fell from 3.1 percent in the 1970s to about 1.3 percent between 1986 and 1991. The service sector was the only source of continuous, positive employment growth, with the construction sector experiencing a volatile employment performance and the other sectors facing declines. Since the 1980s, however, services have experienced a gradual slowdown in the increase of their relative share of employment (Chart 1-1).

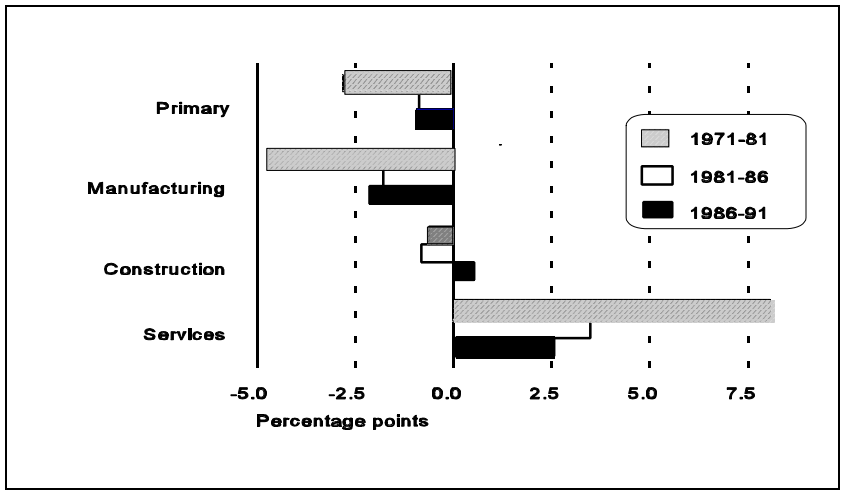
In contrast, the relative importance of manufacturing was severely eroded over the past 20 years as employment grew by a meagre 0.3 percent each year between 1971 and 1991. Manufacturing employment was hard hit during the severe recessions of the early 1980s and the early 1990s as employment fell by nearly 0.6 percent annually during the period 1981-91.

Differences in sectoral employment growth rates are reflected in changes in the absolute shares of sectoral employment over time. The primary, manufacturing, and construction sectors all saw their shares of employment decline over each subperiod while that of the service sector increased. By 1991, services accounted for almost 65 percent of business sector employment (Table 1-2).[1]

Table 1-1
Average Annual Employment Growth in the Business Sector (Compound % Rates), Selected Periods, 1971-91

Industrial Sector	1971-81	1981-86	1986-91	1971-91
Primary	0.44	- 0.85	- 1.18	- 0.27
Manufacturing	1.22	- 0.43	- 0.84	0.28
Construction	2.44	- 0.67	2.51	1.63
Services	4.64	2.37	2.10	3.44
Total Business Sector	3.11	1.19	1.28	2.17

Chart 1-1
Change in Relative Employment Shares in the Business Sector,[1] 1971-91



1 For each period, the change in the employment share of each broad industrial sector is measured in relation to the average rate of growth for the overall business sector.

Table 1-2
Employment Shares in the Business Sector, Selected Years, 1971-91

Industrial Sector	1971	1981	1986	1991
Primary	11.70	9.04	8.16	7.22
Manufacturing	27.81	23.07	21.28	19.15
Construction	9.91	9.21	8.39	8.91
Services	50.58	58.68	62.17	64.73
Total	100.00	100.00	100.00	100.00

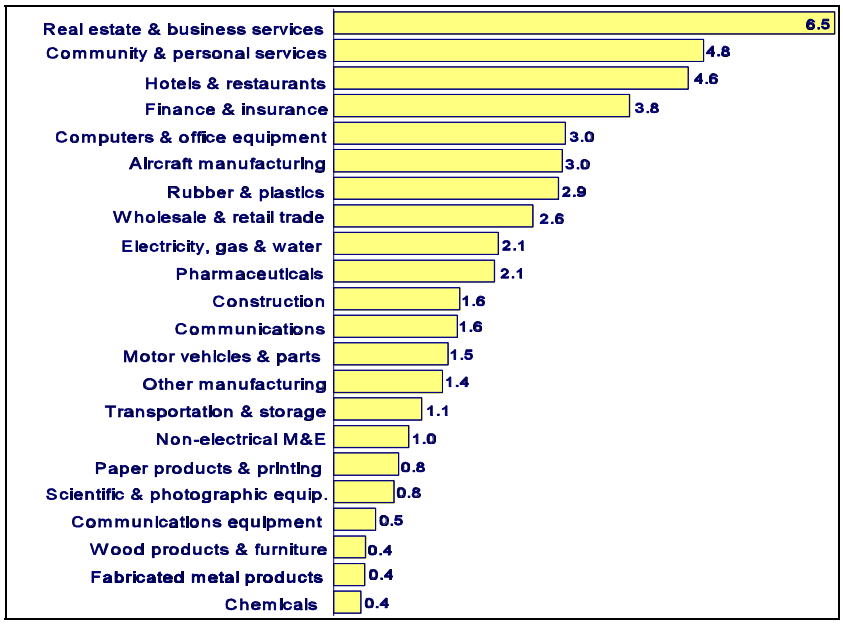
Industries with Growing and Declining Employment

Structural change at the broad sectoral level led to increases in employment in some industries and declines in others.

Chart 1-2 shows employment growth over the period 1971-91 for the growth industries in the business sector. Strong employment growth performances were evident in most industries within the service sector, with employment expanding fastest in real estate and business services. Other service industries, such as community and personal services, hotels and restaurants, finance and insurance, wholesale and retail trade, and communication services, were

also among the fastest-growing industries. This pattern is consistent with that found in other OECD economies (Papaconstantinou, 1995; Sakurai, 1995).

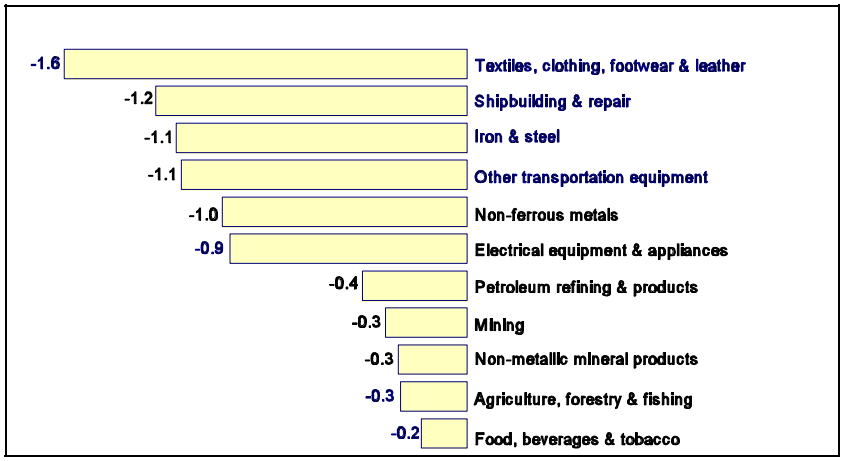
Chart 1-2
Employment Growth in the Business Sector,[1] by Industry, 1971-91



1 Compound average annual growth rates, based on a 33-industry classification.

Despite the overall decline in manufacturing employment, four manufacturing industries are among the top 10 fastest growing industries – computers and office equipment, aircraft manufacturing, rubber and plastics, and pharmaceuticals. However, these industries account for

Chart 1-3
Employment Losses in the Business Sector, by Industry,[1] 1971-91



1 Compound average annual growth rates, based on a 33-industry classification.

only a small part of total employment. In its 1992 study, the OECD noted that in each of the seven countries covered (Australia, Canada, France, Germany, Japan, the United Kingdom, and the United States), the service sector outperformed manufacturing.

At the other end of the scale, the adverse effects of structural change have forced severe adjustments in labour-intensive traditional industries such as textiles, clothing, footwear, and leather. Shipbuilding also exhibited significant job loss (about one quarter) during the period 1971-91. Other manufacturing industries, such as iron and steel, non-ferrous metals, other transportation equipment, and electrical equipment and appliances, also recorded significant employment declines (Chart 1-3).

The Pace of Structural Change

Employment trends provide indirect evidence of the impact of structural transformation on jobs in OECD economies (OECD, 1996). To assess whether or not shifts in the structural composition of employment have accelerated over time, we employ two measures of structural change, also used in the OECD *Jobs Study* (1994). The first indicator, proposed by Lilien (1982), is the weighted standard deviation of annual employment growth by industry. The second, called the dissimilarity index, corresponds to half of the sum of absolute changes in employment shares by industry as proposed by Layard *et al.* (1991).[2] Taking averages over each subperiod (1971-81, 1981-86, and 1986-91) serves to remove the effects of cyclical fluctuations in sectoral employment.

As depicted in Table 1-3, both measures suggest that the pace of structural change – as captured by inter-industry employment shifts – has not been rising. It may have accelerated somewhat during the early 1980s, but in the latter part of the decade and the early 1990s, not only has it not quickened but it may even have slowed down. These results are consistent with the findings of earlier studies (OECD, 1994; Gera & Mang, 1996).

However, a significant part of the rise in the two measures over the subperiod 1981-86 may be the result of 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.[3]

Table 1-3
Measures of Structural Change in the Business Sector,[1] 1971-91

Subperiod	Lilien Index	Dissimilarity Index
1971-81	2.6	1.6
1981-86	3.0	1.7
1986-91	2.7	1.4

1 Average annual inter-industry employment shifts in percentage, based on a 111-industry classification.

2. IS THE STRUCTURE OF EMPLOYMENT SHIFTING TOWARDS KNOWLEDGE-BASED INDUSTRIES?

There is an increasingly widespread view among economists and policy makers that innovation in the uses of people (skills), capital (technology), and ideas (knowledge) is the key to long-term economic growth. On the theoretical front, new growth theory suggests that the accumulation of physical and human capital, and technical change are the driving forces behind economic growth. These sources are, however, not independent of each other (Barro, 1991; De Long & Summers, 1991; Fagerberg, 1994; Grossman & Helpman, 1994; Mankiw, 1995). On the policy front, there is a growing recognition of the desirability of a knowledge-based approach to the setting of policy (Industry Canada, 1994; Human Resource Development Canada, 1994).

The structure of all industrial economies has been changing towards knowledge-driven systems over the past decade. The major industries that have traditionally driven the North American economy have given way to industries whose success is based on knowledge and innovation rather than on large-scale manufacturing muscle (Drucker, 1993; Beck, 1992). 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 spillover benefits; provide high-skill, high-wage employment; attract quality foreign direct investment; and generate higher returns to capital and labour than those available elsewhere in the economy (Katz & Summers, 1989; Bernstein, 1996).

The objective of this chapter is to provide empirical evidence on the hypothesis that innovative industries are critical to job creation in the overall economy and in specific sectors – namely, manufacturing, services, natural resources, and construction.

Employment Performance in the Knowledge Economy

Economists generally agree that it is difficult to assess the impact of knowledge on economic performance since knowledge is inherently differentiated and difficult to quantify (Howitt, 1996). No standard definition exists for high-knowledge industries, and when researchers have attempted to classify industries according to their knowledge intensity, they have generally used a single characteristic for measuring knowledge (Rose, 1992). Some examples of these approaches:

- Ministry of State for Science and Technology (1987) measures knowledge intensity by the level of product sophistication; service sector industries are not included.
- Palda (1986) and Economic Council of Canada (1983) use expenditures on R&D to measure knowledge intensity, but this indicator may misrepresent the actual knowledge or technology level in a small open economy where foreign investment is high.

- Economic Council of Canada (1983) and Wong (1990) define knowledge intensity by the proportion of high-technology inputs embodied in final goods and services, but this approach relies entirely on products and ignores processes as well as the human capital aspect.

- Beck (1992) calculates a knowledge ratio for U.S. industries based on the proportion of professionals and of engineering, technical, scientific, and senior management staff, and assumes that Canadian knowledge industries are the same as in the United States. This definition however, is biased towards knowledge-using rather than knowledge-producing industries (Lee & Has, 1996).
- Rose (1992) defines knowledge intensity as the intensity of use of high-knowledge workers – i.e., the proportion of weeks worked in an industry by people with university degrees. This approach does not take into account a possible mismatch between the level of education and the skill requirements of the job.

Classification

Lee & Has (1996) is probably the best available empirical study to date of the role of knowledge in the Canadian economy. The authors have combined several indicators to measure the knowledge content of an industry. Industries are classified into high-, medium-, and low-knowledge sectors, based on a combination of several indicators of R&D activity and human capital content.

For R&D activity, three indicators 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 (personnel with university-level degrees) in total employment.

The measurement of human capital content also takes into account three indicators: 1) the ratio of workers with postsecondary education[4] to total employment; 2) the ratio of knowledge workers[5] to total employment; and 3) the ratio of the number of employed scientists and engineers to total employment.[6]

In this approach, industries are ranked according to each of the six indicators, and 55 industries are divided into three knowledge groups.[7] An industry is classified as high-knowledge if at least two of its three R&D indicators are among the top third for all industries *and* at least two of its three human capital indicators are also found among the top third for all industries. An industry is defined as low-knowledge if at least two of its three R&D indicators are among the bottom third for all industries *and* at least two of its three human capital indicators are also found among the bottom third for all industries. All remaining industries are classified in the medium-knowledge group.

Appendix Tables A-1 and A-2 present R&D indicators and human capital variables by industry, respectively. For the high-knowledge group, all three R&D indicators exceed the average for all industries (0.52, 0.56, and 0.29, respectively).[8] In contrast, all three R&D indicators for low-knowledge industries are below the average for all industries. In addition, high-knowledge industries generally have above-average human capital content (41.1, 24.6, and 3.6, respectively) while low-knowledge industries have below-average human capital content.[9]

BOX 1

KNOWLEDGE INTENSITY GROUPS

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

In this paper, we use the Lee & Has (1996) classification and map a highly disaggregated level of industries (161) into 55 business sector industries, and then place 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 industries, such as computers, business services, and health and social services. Medium-knowledge manufacturing industries tend to be large, mature sectors whose output is mass-produced and often heavily traded (motor vehicle and parts; other electrical products and electronics; and other transportation equipment). Low-knowledge industries include mostly labour-intensive manufacturing and traditional service industries (retail trade; accommodation and food services; and furniture and clothing industries).

The Overall Business Sector

It is clear that employment in the Canadian economy has been shifting towards high-knowledge industries; this transformation has been evident since the early 1970s.

Since at least 1971, employment growth has been consistently higher in high-knowledge industries than in medium- and low-knowledge industries. The annual rate of employment growth in high-knowledge industries from 1971 to 1991 was almost 2.5 times higher than in medium-knowledge industries and almost twice that in low-knowledge industries (Chart 2-1).[10] Despite this superior performance of high-knowledge industries, a large portion of the Canadian business sector remains in the low- and medium-knowledge groups.

The relative importance of employment in high-knowledge industries has increased over the past 20 years (Chart 2-2). That is not to say that all high-knowledge industries have been experiencing rapid employment growth and that all industries in the low-knowledge group had weak performances. In fact, many service industries in the medium- and low-knowledge groups recorded strong employment increases over the period 1971-91 (Table 2-1).

Chart 2-1
Employment Growth by Level of Knowledge Intensity, Total Business Sector, 1971-91

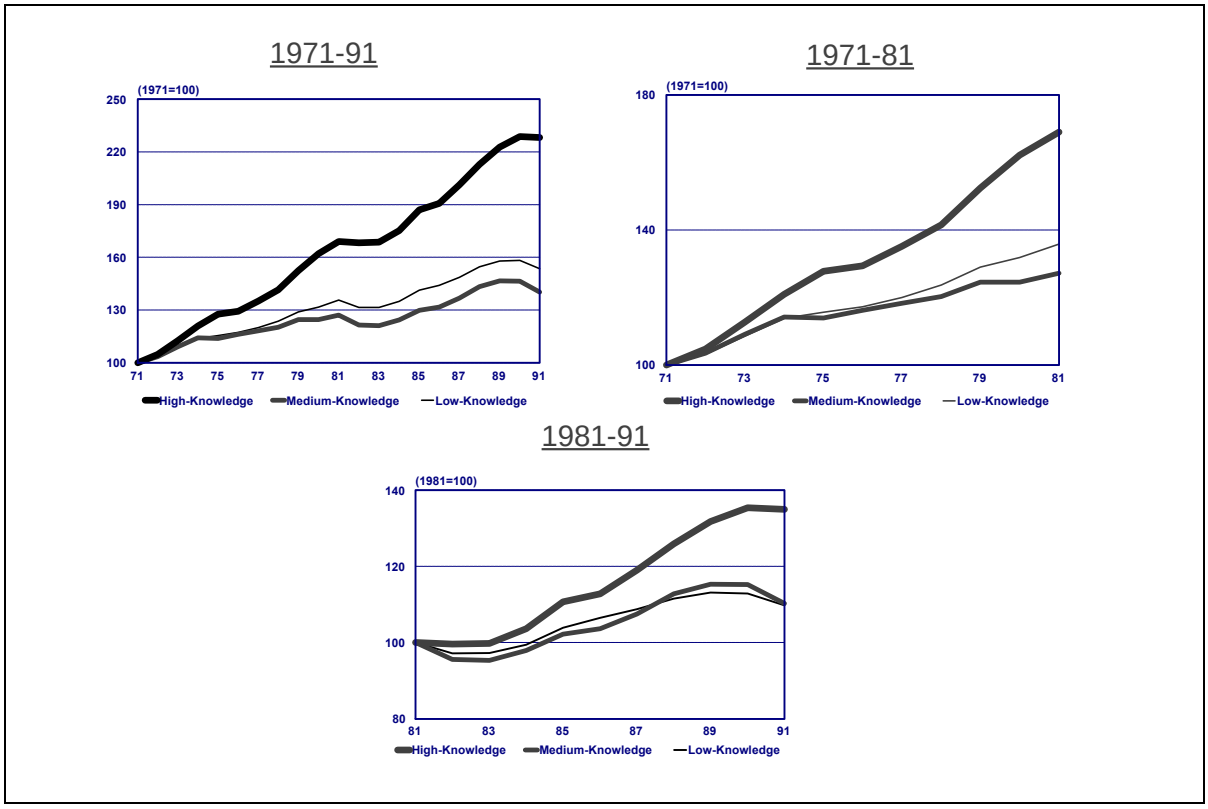


Chart 2-2
Employment Shares by Level of Knowledge Intensity,
Total Business Sector, Selected Years, 1971-91

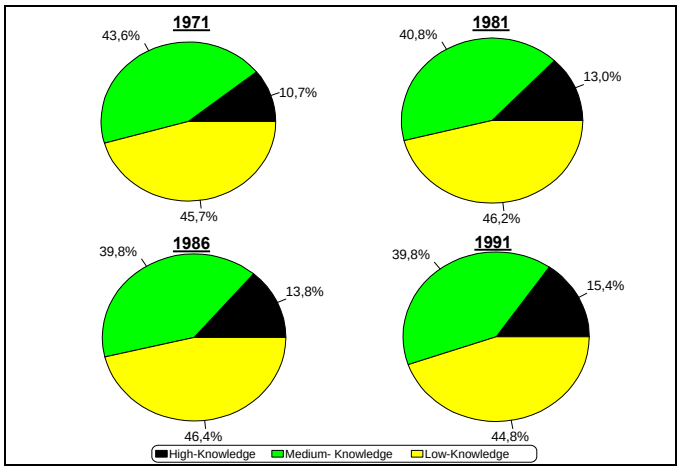


Table 2-1
Annual Average Employment Growth (Compound Rates)
in the Top 20 Business Sector Industries,[1] by Level of Knowledge Intensity, 1971-91

Industries	Knowledge Intensity	Employment Growth Rate (%)
Business Services	High	5.90
Educational Services	High	5.43
Health & Social Services	High	5.41
Personal Services	Low	5.28
Recreation Services	Low	4.98
Accommodation & Food Services	Low	4.59
Plastic Products	Medium	4.55
Fishing & Trapping	Low	3.95
Mineral Fuels	Medium	3.86
Services Incidental to Mining	Medium	3.83
Finance, Real Estate, & Insurance	Medium	3.83
Pipeline Transport	High	3.71
Wholesale Trade	Medium	3.08
Office, Store & Business Machines	High	3.00
Aircraft & Aircraft Parts	High	2.96
Other Services	Low	2.90
Retail Trade	Low	2.39
Electric Power Systems	High	2.15
Pharmaceutical & Medicine Products	High	2.08
Printing & Publishing	Medium	2.06

1 Based on a 55-industry disaggregation.

Table 2-2
Employment Performance in the Business Sector, by Level of Knowledge Intensity, 1981-82 and 1990-91 Recessions

	1981-82 Recession		1990-91 Recession	
Knowledge Intensity	**Employment Loss**	**Proportion of Total Loss (%)**	**Employment Loss**	**Proportion of Total Loss (%)**
High	-3,710	1.5	-3,684	1.3
Medium	-142,774	57.0	-162,328	57.3
Low	-104,098	41.5	-117,207	41.4
Total Job Loss	-250,582	100.0	-283,219	100.0

Three observations are warranted here.

First, employment in the high-knowledge sector is far less sensitive to cyclical downturns than in the medium- and low-knowledge sectors. Employment fell proportionately less in the high-knowledge sector around the 1981-82 and 1990-91 recessions than in the medium- and low-knowledge industries (Table 2-2). Although high-knowledge industries accounted for about 15 percent of business sector employment, only 1.5 percent of all jobs lost during each of those two recessions were in those industries.

Second, high-knowledge industries contributed much more to employment growth than medium- and low-knowledge industries between 1986 to 1991 (Table 2-3), accounting for 41.2 percent of total job gains over this period. This performance was achieved despite the fact that the Canadian economy experienced a series of shocks, including a recession in 1990 and restructuring resulting from factors such as the Canada-U.S. Free Trade Agreement and the macroeconomic policies adopted by the federal and provincial governments (Harris, 1993).

Table 2-3
Distribution of Employment Growth in the Business Sector, by Level of Knowledge Intensity, 1986-91

Knowledge Intensity	**Share of Total Employment (%)**	**Employment Gain**	**Proportion of Total Gain (%)**
High	15.4	229,888	41.2
Medium	39.7	216,220	38.8
Low	44.9	120,019	21.5
All Groups	100.0	557,638	100.0

Table 2-4
The Pace of Structural Change in the Knowledge Economy,[1] 1971-91

Subperiod	Lilien Index	Dissimilarity Index
1971-81	1.67	1.44
1981-86	1.91	1.67
1986-91	1.53	1.35

1 Based on a 55-industry disaggregation.

Finally, the evidence in Table 2-4 on employment shifts between the broad knowledge groups (based on a 55-industry aggregation scheme) shows that the pace of these shifts did not accelerate in the late 1980s and early 1990s. This result is similar to that reported earlier for the 111-industry disaggregation (see Table 1-3).

The Manufacturing Sector

Although the Canadian manufacturing sector accounts for just under 20 percent of total business sector employment, it remains important overall as it plays a leading role in innovation and strongly influences other sectors of the economy, especially as a supplier of capital equipment.

Manufacturing employment in Canada has been on a long-term decline, falling from 28 percent of total employment in 1971 to 19 percent by 1991. This decline has not been uniform in all manufacturing industries, however. In fact, a clear shift can be discerned in the composition of manufacturing employment towards knowledge-intensive industries.

Chart 2-3 shows the growth in manufacturing employment according to the level of knowledge intensity. Over the period 1971-91, the high-knowledge manufacturing group recorded the highest growth of the three groups, led by industries such as office, store, and business machines; aircraft and aircraft parts; pharmaceutical and medicine products; and electronic equipment. In contrast, employment in medium-knowledge industries grew marginally, and low-knowledge industries registered job losses over the same period (Table 2-5).

Canadian manufacturing still remains a predominantly medium-knowledge sector. While structural change is shifting employment towards knowledge-intensive industries, the pace of change has been far from ideal. There were only small changes in the shares of employment out of low-knowledge industries and into high-knowledge industries (Chart 2-4). This is consistent with the finding that the pace of structural change in the manufacturing sector, as in the total

business sector, did not increase between 1986 and 1991, and has remained at about the same level as in the 1970s.

Chart 2-3
Employment in Knowledge-Intensive Industries of the Manufacturing Sector, 1971-91

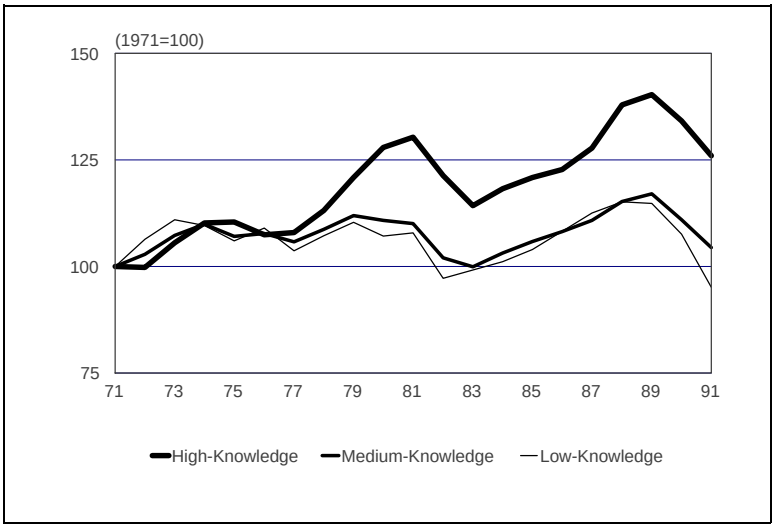


Chart 2-4
Employment Shares in the Manufacturing Sector, by Level of Knowledge Intensity, Selected Years, 1971-91

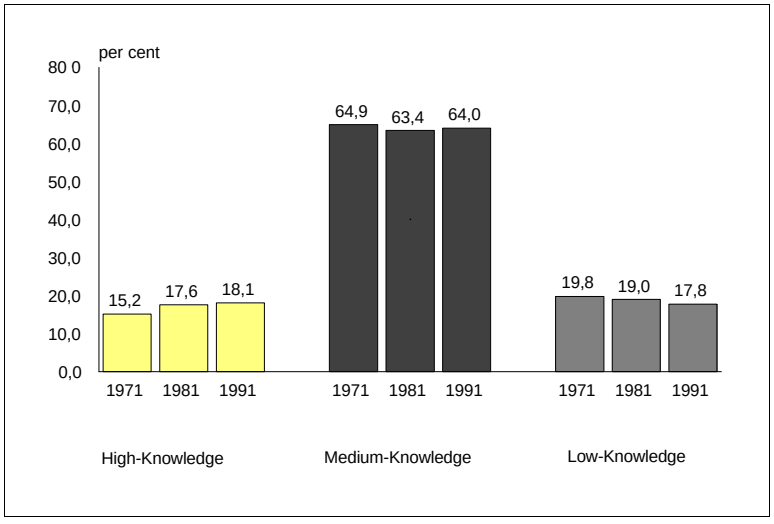


Table 2-5
Average Annual Employment Growth in Manufacturing Industries, by Level of Knowledge Intensity, 1971-91

Industries	Employment Growth Rate (%)
HIGH-KNOWLEDGE	
Office, Store & Business Machines	3.00
Aircraft & Aircraft Parts	2.96
Pharmaceutical & Medicine Products	2.08
Electronic Equipment	1.14
Machinery	1.01
Scientific and Photographic Equipment	0.78
Chemical Industries & Chemical Products	0.35
Refined Petroleum & Coal Products	-0.42
All High-Knowledge Industries	1.16
MEDIUM-KNOWLEDGE	
Plastic Products	4.55
Printing & Publishing	2.06
Motor Vehicles & Parts	1.48
Rubber Products	0.52
Fabricated Metal Products	0.49
Food	0.12
Non-Metallic Mineral Products	-0.27
Paper & Allied Products	-0.34
Primary Metals, Non-ferrous	-0.96
Primary Metals, Ferrous	-1.14
Other Transportation Equipment	-1.17
Textiles	-1.30
Beverage Industries	-1.44
Other Electrical & Electronics	-1.51
Tobacco Products	-3.39
All Medium-Knowledge Industries	0.21
LOW-KNOWLEDGE	
Furniture & Fixtures	1.03
Other Manufacturing Products	1.07
Wood	0.41
Clothing	-1.25
Leather	-3.76
All Low-Knowledge Industries	-0.25

While knowledge intensity is one indicator of innovativeness, some researchers have used other classification schemes based on characteristics such as technology intensity (as measured by R&D expenditures), wages, sector orientation, and skill intensity (OECD, 1994; Sakurai, 1995; Gera & Mang, 1996; Papaconstantinou, 1995; and Baldwin & Raffiquzzaman, 1994). These characteristics obviously have a high degree of correlation with knowledge intensity. The various classification schemes are summarized in Appendix B.

Manufacturing Industries and Technological Intensity

When spending on R&D as a proportion of gross output is used to measure technology intensity,[11] we find that from 1971 to 1991, employment in medium- and high-technology manufacturing industries has expanded while jobs in low-technology industries have been lost (Chart 2-5). The medium-technology group registered the highest growth rates over the sample periods 1971-81 and 1981-86 (Table 2-6). The automobile industry and rubber and plastic industries had the largest gains in this group. Employment gains in the high-technology industries were led by aircraft and aircraft parts; office, store, and business machines; and the pharmaceutical and medicine industries (Table 2-7).

The industry-level evidence that the more technology-intensive industries are the major job creators in the manufacturing sector is corroborated by firm level-evidence, which shows that firms placing greater emphasis on their ability to adopt technology and develop their R&D capability have faster employment growth than those which invest relatively little in innovation (Baldwin, Rafiquzzaman & Chandler, 1994).

Chart 2-5
Employment in the Manufacturing Sector,
by Level of Technology Intensity, 1971-91

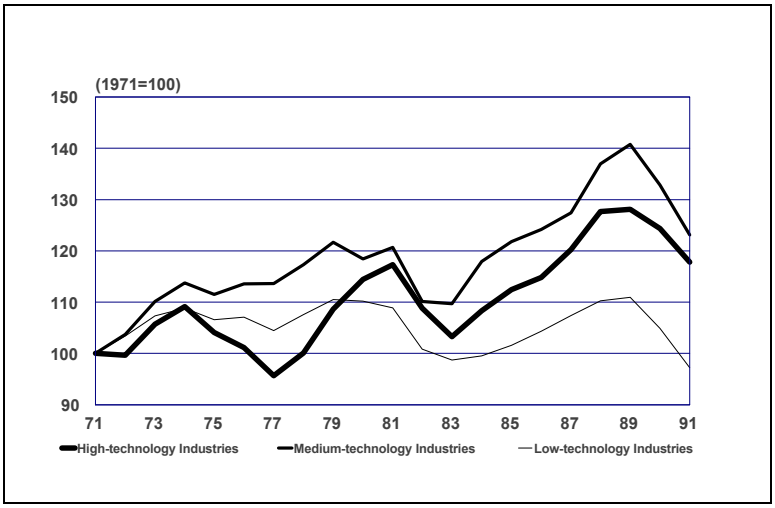


Table 2-6
Average Annual Employment Growth in the Manufacturing Sector (Compound % Rates), by Level of Technology Intensity, 1971-91

Technology Intensity	1971-81	1981-86	1986-91	1981-91	1971-91
High	1.84	-0.42	0.51	0.04	0.82
Medium	1.77	0.56	-0.17	0.20	1.04
Low	0.89	-0.85	-1.40	-1.13	-0.14
Total Manufacturing	1.22	-0.43	-0.84	-0.63	0.28

Table 2-7
Average Annual Employment Growth in Manufacturing Industries (Compound Rates),[1] by Level of Technology Intensity, 1971-91

Industries	Employment Growth Rate (%)
HIGH-TECHNOLOGY	
Pharmaceuticals and Medicine Products	2.08
Computers & Office Equipment	3.00
Electrical Equipment & Appliances	-0.93
Communications Equipment & Components	0.54
Aircraft Manufacturing	2.96
Scientific & Photographic Equipment	0.78
All High-Technology Industries	0.82
MEDIUM-TECHNOLOGY	
Chemicals	0.35
Rubber & Plastics	2.91
Non-Ferrous Metals	-0.96
Non-Electrical Machinery & Equipment	0.97
Other Transportation Equipment	-1.12
Motor Vehicles & Parts	1.48
Other Manufacturing	1.41
All Medium-Technology Industries	1.04
LOW-TECHNOLOGY	
Food, Beverages & Tobacco	-0.18
Textiles, Clothing & Footwear	-1.58
Wood, Wood Products & Furniture	0.41
Paper, Paper Products & Printing	0.84
Petroleum Refining and Products	-0.41
Non-Metallic Mineral Products	-0.27
Iron & Steel	-1.14
Fabricated Metal Products	0.40
Shipbuilding & Repair	-1.22
All Low-Technology Industries	-0.14

Table 2-8
Distribution of Manufacturing Employment by Level of Technology, Selected Years, 1971-91

Technology Intensity	1971	1981	1986	1991
High	10.9	11.5	11.3	12.1
Medium	24.2	25.6	27.3	28.2
Low	64.9	62.9	61.4	59.7
Total	100.0	100.0	100.0	100.0

While high-technology industries have seen their share of employment increase over the past 20 years, the Canadian manufacturing sector remains predominately a low- to medium-technology sector. In 1991, some 89 percent of employment was concentrated in low- and medium-technology manufacturers (Table 2-8). The data on manufacturing output in Canada also shows similar trends (Gera & Mang, 1996).

By international standards, the employment performance of Canadian high-technology industries has been mediocre. In the OECD area as a whole, employment in high-technology industries represented about 20 percent of total manufacturing employment in 1991 – an increase of 5 percentage points since 1970 (Table 2-9). In contrast, high-technology industries only accounted for about 12 percent of Canadian manufacturing employment in 1991 – only about 1 percentage point higher than in 1971.

Table 2-9
Employment in High-Technology Manufacturing Industries, G-7 Countries, 1970-91

Countries	Numbers (000s)	Percentage of Manufacturing Employment		Percentage of Total Business Sector Employment		Average Annual Growth Rate of Employment in High-tech Industries		
	1991	1970	1991	1970	1991	1970-80	1980-91	1970-91
United States	3,874.6	17.6	21.0	4.9	4.0	2.0	-0.4	0.7
Japan	3,441.3	16.0	21.8	4.9	4.2	0.6	3.1	1.9
Germany	1,823.7	16.5	20.1	7.1	6.5	-0.5	1.2	0.4
United Kingdom	1,031.6	16.3	19.4	6.8	6.1	-1.1	-1.7	-1.4
France	804.5	14.0	18.4	4.5	4.8	0.6	-0.2	0.1
Italy	553.5	10.2	10.9	3.1	3.3	0.5	0.6	0.00
Canada	209.1	10.9[a]	12.1	3.0[a]	2.3	1.8[b]	0.04[c]	0.4[d]

a 1971. b 1971-81. c 1981-91. d 1971-91.

Source: OECD (1994); and estimates by the authors, based on data from Statistics Canada.

When we consider manufacturing value-added, the message is the same. While the part of manufacturing value-added that is accounted for by high-technology industries has increased in every OECD country between 1970 and 1989, the corresponding indicator for Canada has been markedly lower than in some of the major industrialized economies (OECD, 1994) – namely, about 11 percent, versus about 24 percent for the United States, 22 percent for Japan and the United Kingdom, 21 percent for Germany, 19 percent for France, and 13 percent for Italy. Weak growth in the share of value-added may explain Canada's relatively inferior performance in high-technology export markets, and hence in high-technology employment.[12]

High-technology industries play a key role for other sectors of the economy as they generate significant spillover effects, including the development of new technologies that contribute to higher productivity and output growth. The relatively lower share of the high-tech industries among all Canadian industries and their inferior performance in export markets may be a symptom of an "innovation gap." There is a widely held view that Canadian industry suffers from an innovation gap compared to other developed countries (OECD, 1995). This view is based on the fact that Canada's R&D expenditure as a share of GDP is among the lowest in the OECD area, both in the private sector and overall; and that Canada's patent indicators, such as the number of domestic patents granted to residents (on a per capita basis), the number of patents filed within the country, as well as the number of scientists and engineers per person in the labour force, all show that Canada consistently displays some of the lowest ratios in the industrialized world.

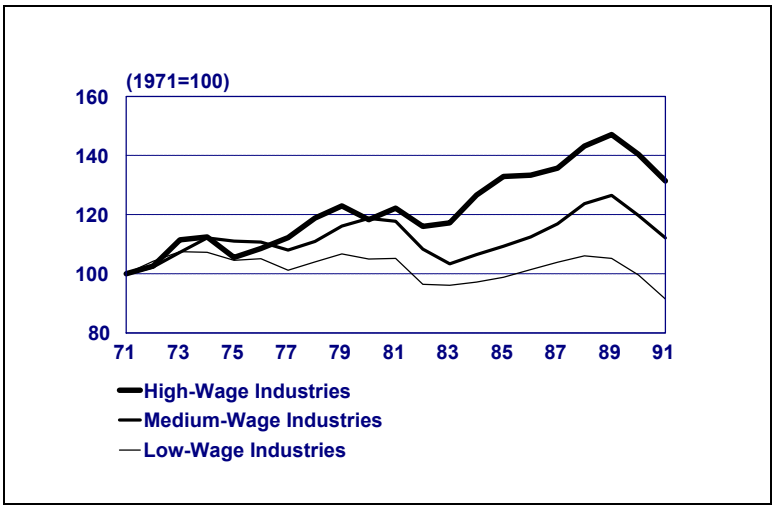
However, the reliability of these indicators has been criticized because of the relatively high foreign ownership levels in Canadian industry. Evidence on the rates of adoption of new technologies suggests that advanced technologies are used extensively in the Canadian manufacturing sector. Almost one half (48 percent) of manufacturing establishments use at least one advanced manufacturing technology (Baldwin, Diverty & Sabourin, 1995). Thus R&D and patent data may overstate the magnitude of any innovation gap between Canada and other industrialized countries.

Wage Intensity

The increased importance of the high-knowledge, high-technology sectors has implications on wages paid in the Canadian labour market. Studies show that wages paid by high-tech and high-knowledge industries are typically higher than the average wage in the economy (OECD, 1994).

For the purposes of this analysis, manufacturing industries are grouped into high-, medium-, and low-wage groups.[13] Chart 2-6 shows that high-wage manufacturing industries registered the highest employment growth over the past 20 years. The medium-wage category also had more jobs in 1991 than in 1971, while low-wage industries shed jobs during

Chart 2-6
Manufacturing Employment Growth, by Wage Level, 1971-91



the period. Clearly, the economy is shifting out of low-wage manufacturing employment and into high- and medium-wage jobs.

The high-wage manufacturing group recorded the highest employment growth, at 1.4 percent per year, over the 1971-91 period. Again, computer and office equipment, aircraft, and pharmaceuticals enjoyed strong growth. Among medium-wage industries, rubber and plastics stand out as strong performers, while low-wage industries lost over 59,000 manufacturing jobs over the same period (Table 2-10). Although high-wage employment is only a small part of manufacturing employment, it plays a leading role in job creation in that sector. The net increase in both high- and medium-wage groups more than offset the decrease in low-wage employment (Table 2-11).

Table 2-10
Average Annual Employment Growth in the Manufacturing Sector (Compound % Rates), by Wage Level, Selected Periods, 1971-91

Wage Level	1971-81	1981-86	1986-91	1981-91	1971-91
High	2.00	1.76	-0.29	0.73	1.37
Medium	1.64	-0.96	-0.03	-0.49	0.53
Low	0.47	-0.72	-2.05	-1.39	-0.45
Total Manufacturing	1.22	-0.43	-0.84	-0.63	0.28

Table 2-11
Distribution of Manufacturing Employment by Wage Levels, Selected Years, 1971-91

Wage Level	1971	1981	1986	1991
High	14.2	15.4	17.1	17.6
Medium	43.6	45.2	44.0	45.8
Low	42.3	39.4	38.9	36.5
Total	100.0	100.0	100.0	100.0

Skill Intensity

The growing importance of knowledge- and technology-intensive sectors has implications for skill requirements and the composition of employment in the Canadian labour market. The manner in which technological sophistication affects the demand for particular types of skills has special policy significance.

Here, we classify manufacturing industries in terms of their skill content, as measured by the ratio of production vs. non-production workers. This classification shows that employment in skilled and unskilled industries has evolved very differently. From 1971 to 1991, employment grew faster in manufacturing industries where skilled employees are the majority, while the employment in industries that use a majority of less skilled workers showed no trend increase. While skilled and unskilled employment followed similar patterns in the 1970s, skilled jobs were created at a faster pace in the 1980s (Chart 2-7).

Chart 2-7
Manufacturing Employment Growth, by Skill Intensity, 1971-91

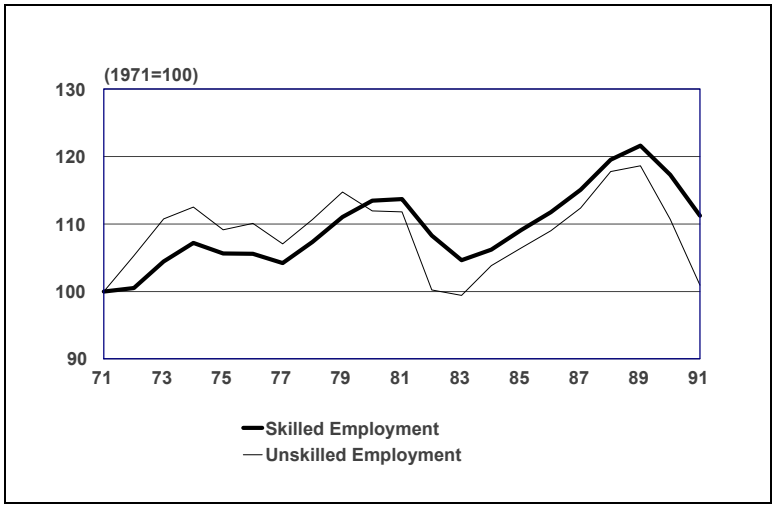


Table 2-12
Average Annual Employment Growth in the Manufacturing Sector (Compound % Rates), by Level of Skill Intensity, Selected Periods, 1971-91

Skill Intensity	1971-81	1981-86	1986-91	1981-91	1971-91
High	1.39	-0.34	-0.09	-0.22	0.53
Low	1.07	-0.51	-1.52	-1.01	0.05

Table 2-13
Distribution of Manufacturing Employment by Level of Skill Intensity, Selected Years, 1971-91

Skill Intensity	1971	1981	1986	1991
High	46.5	46.9	47.1	48.9
Low	53.5	53.1	52.9	51.1
Total	100.0	100.0	100.0	100.0

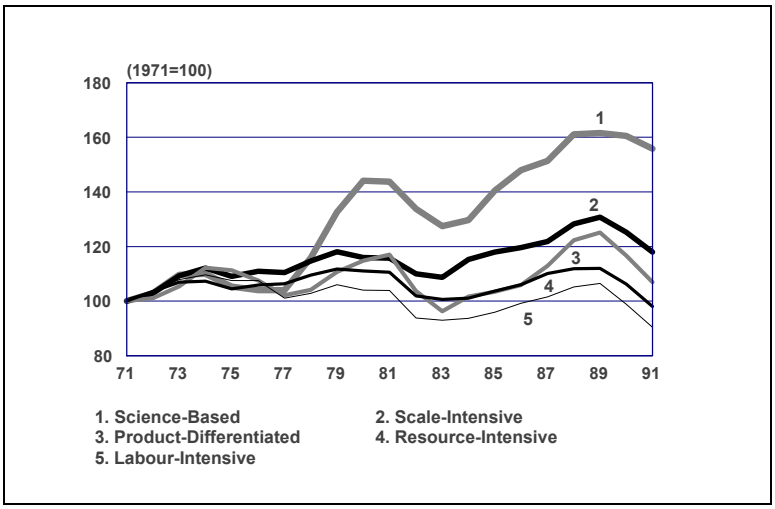
During the 1971-91 period, jobs in high-skill manufacturing industries increased, on average, by a little over 0.5 percent per year, while jobs in low-skill industries remained almost unchanged (Table 2-12). Among the high-skill industries, computers and office equipment, pharmaceuticals, and communication equipment enjoyed strong employment growth rates. The largest increase in the low-skill sector was in rubber and plastics, motor vehicles and parts, and other manufacturing.

High- and low-skill manufacturing accounted for roughly equal shares of employment in 1991, although the proportion of the high-skill sector increased more rapidly in the late 1980s than in the 1970s (Table 2-13). According to the OECD *Jobs Study* (1994), Japan and Canada recorded the largest increase in the share of skilled employment among the G-7 economies. Unskilled manufacturing employment declined most rapidly in France and the United Kingdom.

Sector Orientation

In this section, manufacturing industries are classified according to their orientation or to the main factors believed to affect competitiveness in each industry. Five groups are thus formed: natural resource-based, labour-intensive, product-differentiated, scale-based, and science-based industries (OECD, 1994; Gera & Mang, 1996).[14]

Chart 2-8
Manufacturing Employment Growth, by Sector Orientation, 1971-91



Between 1971 and 1991, science-based industries – i.e., those with rapid application of scientific advancements – had the strongest job expansion. Jobs in the scale-intensive industries and specialized suppliers group – industries with broad product differentiation – also increased but at a relatively slow pace. In contrast, resource- and labour-intensive industries shed jobs during the period (Chart 2-8 and Table 2-14).

Science-based industries – led by computers and office equipment, aircraft manufacturing, and pharmaceuticals – recorded the highest growth rates during the 1971-91 period (2.24 percent per year). Scale-intensive industries had their best performance between 1981 and 1986, with motor vehicles and parts, and rubber and plastics making the major contributions. Communications equipment and components was the only product-differentiated industry to enjoy strong growth rates in the latter half of the 1980s.

Table 2-14
Average Annual Employment Growth in the Manufacturing Sector (Compound % Rates), by Sector Orientation, 1971-91

	1971-81	1981-86	1986-91	1981-91	1971-91
Science-Based	4.12	0.58	1.04	0.81	2.24
Scale-Intensive	1.49	0.67	-0.28	0.19	0.83
Product-Differentiated	1.60	-1.98	0.19	-0.90	0.34
Resource-Intensive	1.06	-0. 83	-1.57	-1.20	-0.10
Labour-Intensive	0.27	-0.92	-1.86	-1.39	-0.51
Total Manufacturing	1.22	-0.43	-0.84	-0.63	0.28

Table 2-15
Distribution of Manufacturing Employment by Sector Orientation, Selected Years, 1971-91

Sector Orientation	1971	1981	1986	1991
Natural Resource-Intensive	28.9	28.4	27.8	26.8
Labour-Intensive	24.0	22.1	21.6	20.5
Product-Differentiated	12.1	12.6	11.6	12.2
Scale-Intensive	31.1	31.9	33.7	34.7
Science-Based	3.9	5.0	5.3	5.8
Total	100.0	100.0	100.0	100.0

Scale-intensive and natural resource-based manufacturing sectors represented respectively the largest and second-largest shares of employment throughout the 1971-91 period. These two groups combined accounted for almost two thirds of manufacturing employment in 1991. Science-based industries, while continuing to expand, accounted for the smallest share of manufacturing employment. The share of employment in labour-intensive industries declined the most in this group, falling by about 4 percentage points between 1971 and 1991 (Table 2-15).

In summary, there seems to be clear evidence that the composition of Canadian manufacturing employment is shifting towards more knowledge-intensive activities. Low-knowledge, low-technology, low-skill, low-wage, and labour-intensive jobs are being shed while high-knowledge, high- and medium- technology, science-based, high-skill, and high-wage employment is continuing to expand. These trends seem to be consistent with those of many other OECD economies (see, for example, OECD, 1994).

The Pace of Change in Manufacturing

These results confirm earlier findings that compositional shifts in employment within the manufacturing sector did not accelerate in the late 1980s (Table 2-16).

Table 2-16
Average Pace of Structural Change in the Manufacturing Sector,[1] Selected Periods, 1971-91

Subperiods	Lilien Index	Dissimilarity Index
1971-81	2.64	2.1
1981-86	3.0	2.5
1986-91	2.7	2.1

1 Based on an 85-industry disaggregation.

Structural Shifts in the Service Sector

Although the service sector accounts for about 60 percent of business sector GDP and employment, and has been the principal source of net job gains over the 1980s, this sector has not been studied as much as manufacturing.[15] Here, we focus on employment shifts within the service sector by examining industries according to their level of knowledge intensity. Note that for present purposes, services do not include utilities.

Chart 2-9 shows employment growth in the service sector for the three knowledge groups. Service employment continued to increase in all three over the period 1971-91. As in manufacturing, high-knowledge service industries greatly outperformed the other groups.

Rates of expansion in all three high-knowledge service industries – business, educational, and health and social services – were the fastest by far (Table 2-17). Among medium-knowledge industries, recreation services; finance, insurance, and real estate; wholesale trade; and services incidental to mining all enjoyed very strong growth rates over the same period. Although as a group low-knowledge industries grew more slowly, personal services as well as accommodation and food services were among the fastest growing industries.

Within the service sector, the share of total employment accounted for by the high-knowledge group increased by over 6 percentage points between 1971 and 1991. This increase largely came at the expense of low-knowledge services. However, the low-knowledge group still constituted over half of total service sector employment in 1991 (Table 2-18). Medium-knowledge industries, though growing, registered marginal gains in their share of employment.

Chart 2-9
Employment in the Service Sector, by Level of Knowledge Intensity, 1971-91

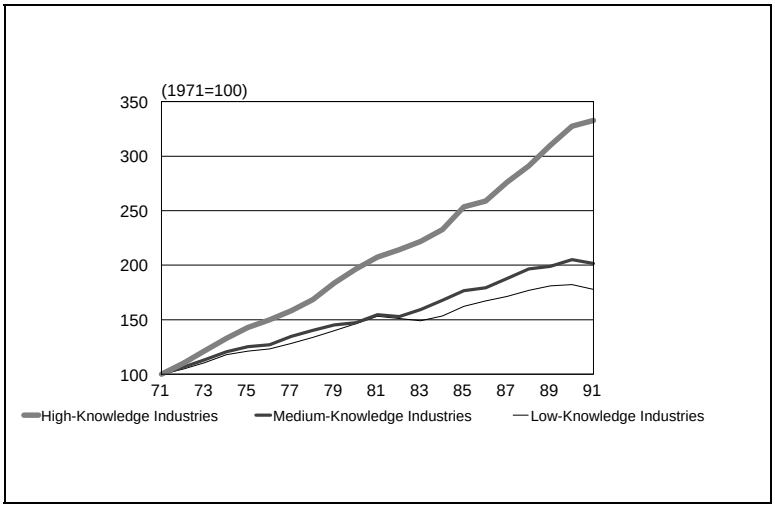


Table 2-17
Average Annual Employment Growth in Services (Compound Rates), by Level of Knowledge Intensity, 1971-91

Knowledge Intensity	Employment Growth Rate (%)
HIGH	
Business Services	5.90
Educational Services	5.43
Health & Social Services	5.41
All High-Knowledge Services	5.78
MEDIUM	
Recreation Services	4.98
Finance, Insurance & Real Estate	3.83
Services Incidental to Mining	3.83
Wholesale Trade	3.08
All Medium-Knowledge Services	3.57
LOW	
Personal Services	5.28
Accommodation & Food Services	4.59
Other Services	2.90
Retail Trade	2.39
Storage & Warehousing	1.41
Transportation Services	0.92
All Low-Knowledge Services	2.96

If one considers employment in utilities, which are classified either as high- or medium-knowledge industries, it can be seen that growth was much slower than in business-sector services (Table 2-19).

In summary, the service sector has also experienced structural change in the direction of greater knowledge intensity.

Table 2-18
Distribution of Employment in the Service Sector, by Level of Knowledge Intensity, Selected Years, 1971-91

Knowledge Intensity	1971	1981	1986	1991
High	11.4	13.9	15.2	17.6
Medium	25.9	25.2	25.8	26.2
Low	62.7	60.9	58.9	56.3
Total	100.0	100.0	100.0	100.0

Table 2-19
Average Annual Employment Growth in Utilities, by Level of Knowledge Intensity, 1971-91

Knowledge Intensity	Employment Growth Rate
HIGH	
Pipeline Transport	3.71
Electric Power Systems	2.15
Total	2.24
MEDIUM	
Gas Distribution Systems	2.00
Telecommunications	1.79
Total	1.80

Table 2-20
The Pace of Structural Change in the Service Sector,[1] 1971-91

Subperiods	Lilien Index	Dissimilarity Index
1971-81	1.24	0.95
1981-86	1.57	1.38
1986-91	1.06	0.97

1 Based on a 13-industry disaggregation (excluding utilities).

The Pace of Change in the Service Sector

The pace of structural change within services (excluding utilities) was much slower than that in the manufacturing sector. As in manufacturing, however, it did not accelerate over the latter part of the 1980s (Table 2-20).

Structural Shifts in the Natural Resources Sector

The natural resources sector includes agriculture; fishing and trapping; forestry; mining; mineral fuels; and quarries and sand pits. The share of this group in overall business sector employment has been declining over the past two decades, falling from 11.7 percent in 1971 to 7 percent in 1991. This sector is predominantly composed of medium- to low-knowledge industries. Table 2-21 shows employment growth for each of these industries over the period 1971-91. In general, natural resource industries are losing employment. Only two – mineral fuels (medium-knowledge) and fishing and trapping (low-knowledge) – recorded strong employment growth.

Table 2-21
Average Annual Employment Growth in the Natural Resources Sector (Compound Rates), by Level of Knowledge Intensity, 1971-91

Knowledge Intensity	Employment Growth Rate (%)
MEDIUM	
Mineral Fuels	3.86
Non-Metal Mines	-0.55
Metal Mines	-2.53
All Medium-Knowledge Industries	-0.41
LOW	
Fishing & Trapping	3.95
Quarries & Sand Pits	0.62
Agriculture	-0.49
Forestry	-0.55
All Low-Knowledge Industries	-0.25

Structural Shifts in the Construction Industry

The construction industry, classified as a medium-knowledge sector, is an important part of the Canadian economy, accounting for about 11 percent of gross output (in 1986 dollars) and 8.5 percent of business sector employment in 1991. However, its relative importance has diminished as its share of value added to the economy declined from 7.5 percent in 1971 to 5.5 percent in 1991.

Employment in the construction industry grew by about 1.5 percent annually between 1971 and 1991. In contrast, manufacturing employment only grew at an annual rate of 0.3 percent over the same period. Construction employment has generally fluctuated between 9.6 and 8.5 percent of total business sector employment (Table 2-22).

Table 2-22
Employment Performance in the Construction Industry, 1971-91

Average Annual Employment Growth (Compound % Rates)				Share of Business Sector Employment			
1971-81	1981-86	1986-91	1971-91	1971	1981	1986	1991
2.21	-0.63	2.64	1.54	9.6	8.7	7.9	8.5

Summary

The evidence presented above indicates that employment growth in Canada is increasingly related to the use and production of knowledge and that the structure of employment is shifting towards high-knowledge and technology-intensive industries. In addition, an increasing proportion of employment is accounted for by industries that require workers with more skills and that pay higher wages. As a result, knowledge-intensive industries now play a more important role in the generation of wealth in the Canadian economy. This development is not a recent one but is part of a process that has been under way since at least the early 1970s.

Although the direction of change has been towards knowledge- and technology-intensive industries, these industries still account for only a small share of overall employment in Canada. The majority of jobs remain concentrated in the low- to medium-knowledge industrial system.

As OECD (1996) points out, the Canadian manufacturing sector is suffering from an innovation gap. This observation seems plausible, given the fact that the Canadian high-technology manufacturing sector is much smaller than that of other major industrialized economies and that the growth of this sector over the last two decades has been much slower. If, as we contend in this study, employment is increasingly related to knowledge-intensive activities, it appears that the closing of the innovation gap will be key to growth in productivity and employment, and hence to future growth in Canadian living standards.

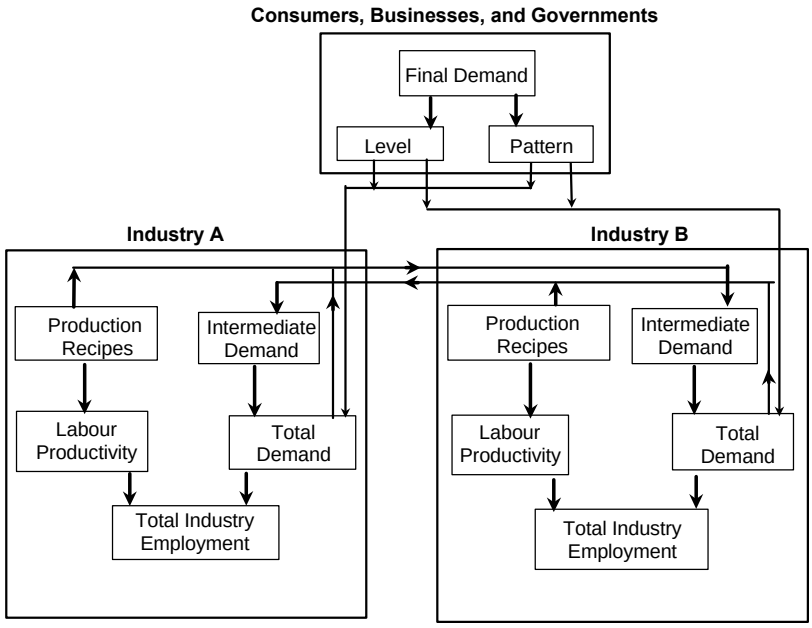
3. SOURCES OF EMPLOYMENT GROWTH

What factors contributed to structural shifts in employment over the period 1971-91? In this chapter, input/output (I/O) techniques are used to decompose employment growth into six factors:

- changes associated with domestic final demand (DFD) – i.e., changes in personal consumption, in business 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 in labour productivity (i.e., in the labour/output ratio);
- changes associated with other factors, such as changes in market shares and in other leakages in the substitution of final demand and intermediate goods.

I/O techniques are particularly useful because they capture flows of goods and services between different industries and allow the indirect effects of these linkages to be captured. I/O techniques also permit the calculation of the contribution of changing production techniques to employment growth. Because changing production 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 (Chart 3-1). The detailed employment decomposition methodology used in this study is explained in Appendix C.

Chart 3-1
Linkages Between Demand, Production Recipes, and Employment



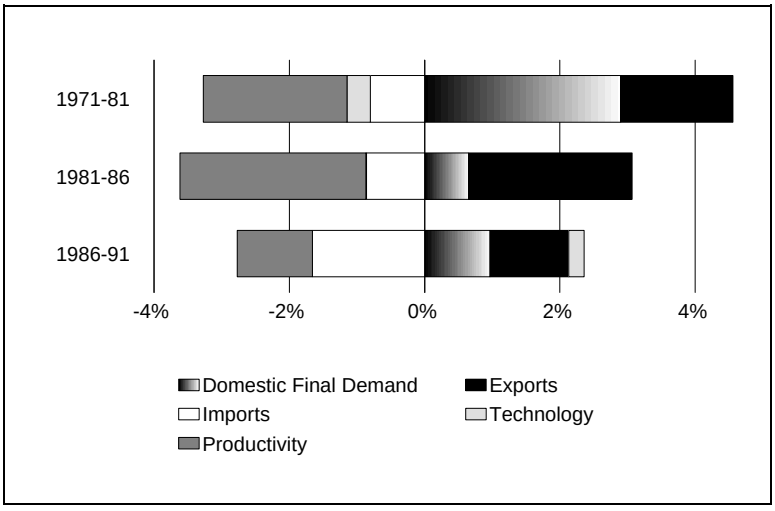
Note that the I/O approach has been criticized on many grounds. These include: the absence of any behavioural content, the static nature of the analysis, the assumption of fixed input/output labour coefficients, and the failure to account for the effects of scale economies. For example, labour productivity growth in our accounting framework is solely labour-saving as it does not take into account any of the price and income effects. Innovations, whether they lower costs or create new products, result in higher wages and profits or in price reductions. All of these tend to increase real incomes, demand for goods and services, and consequently employment. In addition, the six factors of the decomposition analysis may not be independent of each other. For example, gains in labour productivity tend to increase both domestic final demand and exports. Alternatively, import competition may lead to increases in productivity. Although this latter argument seems valid, neither existing endogenous growth models nor the existing empirical evidence on the subject seem to support this conclusion (Baldwin, 1994).

The last source of employment change – that associated with changes in market shares and in other leakages in the substitution of final demand and intermediate goods – warrants further discussion. The term measures the effects of market shares in the sense that some industries may have gained market share at the expense of others. The term also groups all the remaining effects that can be captured with the I/O model. They include changes in the share of supply that comes from government production, from inventories, or from other miscellaneous leakages of intermediate or final goods. The contribution of this factor to employment change is relatively small, and we do not report it in the tables presented later on in this chapter.

The Manufacturing Sector

Chart 3-2 shows the decomposition of employment growth in the manufacturing sector over three subperiods – 1971-81, 1981-86, and 1986-91. The chart reveals that while domestic final demand was the most important contributor to that growth during the 1970s, trade has

Chart 3-2
Sources of Employment Growth in Manufacturing, 1971-91



since become the dominant factor, especially in the 1980s, reflecting the shift towards freer trade and a global marketplace. In the most recent period, changes in production techniques have begun to have a positive effect on employment growth, and import penetration is emerging as a major factor in the deceleration of employment growth in manufacturing.

Labour productivity affected employment negatively in all sample periods. This merely reflects the mechanical nature of labour productivity – i.e., labour saving – since the I/O model does not take into account any of the compensatory effects of lower prices and higher incomes mentioned above. Nonetheless, the positive effect of higher domestic demand and exports typically outweighed the labour-saving effect of productivity increases.

Knowledge-Intensive Manufacturing

High-Knowledge Industries

Although employment in high-knowledge industries is only a small part of manufacturing employment overall, it played a significant role in job creation in that sector. Though rapid productivity increases and import penetration cancelled out most of the potential employment gains, except for the 1986-91 period, these industries enjoyed positive employment growth rates thanks to strong exports and, to a lesser degree, to domestic final demand (Chart 3-3).

Looking at individual manufacturing industries, we find that employment in the office, store, and business machines, aerospace, and communications and other electronic equipment industries depended heavily on export-led growth; technological changes also made positive contributions. In contrast, the increase in employment in the pharmaceutical and medicine industry is mainly attributable to domestic final demand (Table 3-1).

Chart 3-3
Sources of Employment Growth in the High-Knowledge Manufacturing Sector, 1971-91

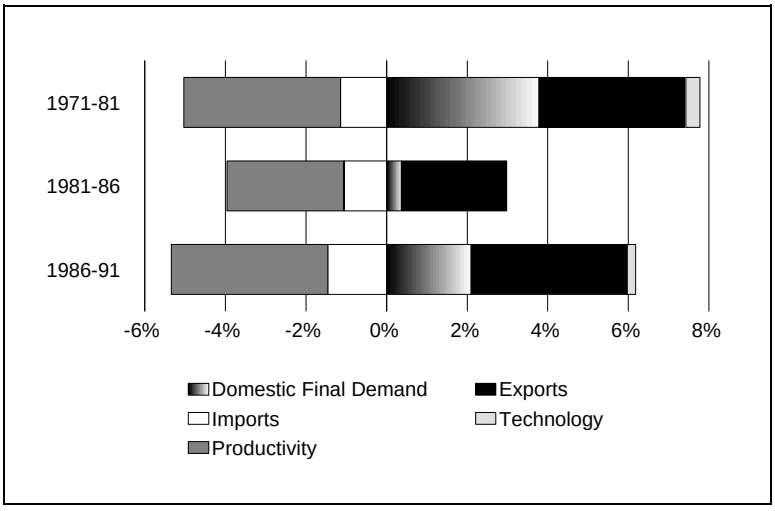


Table 3-1
Sources of Employment Growth in High-Knowledge Manufacturing Industries, Selected Periods, 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	Domestic Final Demand	Exports	Import Penetration	Technological Change	Productivity
1971-81						
Scientific & Photographic Equipment	3.53	3.91	2.15	-1.85	0.55	0.04
Electronic Equipment	0.36	4.77	4.74	-2.95	0.87	-7.87
Aircraft & Aircraft Parts	5.04	2.37	6.05	1.22	0.25	-3.77
Office, Store & Business Equipment	6.39	15.47	18.21	-13.35	2.54	-18.68
Pharmaceutical & Medicine	1.37	4.22	0.65	-0.62	1.08	-2.94
Chemicals & Chemical Products	1.33	2.85	2.07	-0.01	0.40	-4.02
Machinery	3.93	2.99	2.81	-0.42	-0.29	-1.43
Refined Petroleum	4.22	2.36	1.07	0.58	-0.58	0.50
Total	2.80	3.78	3.65	-1.14	0.35	-3.89
1981-86						
Scientific & Photographic Equipment	1.29	1.04	2.53	-1.03	-0.26	-1.90
Electronic Equipment	1.54	0.53	4.34	-0.78	0.93	-4.90
Aircraft & Aircraft Parts	-0.12	-1.51	0.05	0.71	0.18	2.69
Office, Store & Business Equipment	0.57	4.04	27.01	-3.25	0.78	-19.04
Pharmaceutical & Medicine	1.29	4.00	0.24	-0.28	-0.83	-3.63
Chemicals & Chemical Products	-0.93	0.96	2.17	-0.92	0.01	-3.23
Machinery	-3.37	-0.67	-0.83	-1.69	-0.37	-0.64
Refined Petroleum	-8.17	-0.93	1.24	-1.59	-1.19	-4.49
Total	-1.19	0.37	2.61	-1.05	-0.02	-2.89
1986-91						
Scientific & Photographic Equipment	-1.64	1.72	4.48	-3.73	1.01	-2.44
Electronic Equipment	2.37	4.56	7.73	-0.63	0.63	-12.56
Aircraft & Aircraft Parts	2.11	1.08	4.82	-0.14	0.63	-5.04
Office, Store & Business Equipment	-1.68	2.04	18.89	-1.25	0.40	-23.13
Pharmaceutical & Medicine	4.31	4.07	0.48	-0.66	0.10	0.51
Chemicals & Chemical Products	-0.28	1.33	2.06	-3.21	-0.11	0.29
Machinery	-0.31	1.53	0.16	-0.81	-0.10	1.25
Refined Petroleum	-1.44	0.78	1.98	-1.05	-0.61	-2.28
Total	0.52	2.10	3.87	-1.46	0.21	-3.88

Medium-Knowledge Industries

Domestic final demand was by far the most important factor driving employment growth in medium-knowledge manufacturing industries during the 1971-81 period. 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 relatively larger, reflecting changes in comparative advantage in these industries (Chart 3-4).

Chart 3-4
Sources of Employment Growth in the Medium-Knowledge Manufacturing Sector, 1971-91

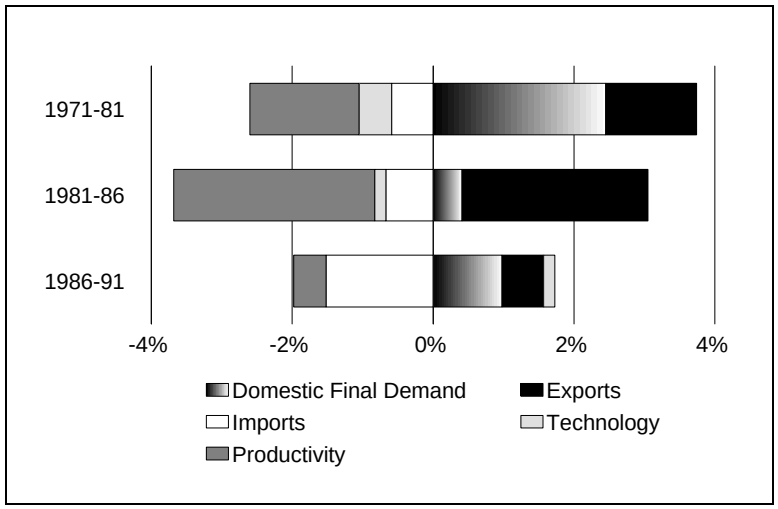


Table 3-2
Sources of Employment Growth in Medium-Knowledge Manufacturing Industries, Selected Periods, 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	Domestic Final Demand	Exports	Import Penetration	Technological Change	Productivity
1971-81						
Other Transportation Equipment	1.46	2.25	0.18	-0.92	0.33	0.47
Other Electrical & Electronics	0.35	1.54	0.53	-0.47	-0.31	-0.82
Primary Metals, Non-Ferrous	0.72	1.25	0.90	-0.59	-0.19	-0.31
Textiles	-0.61	3.39	1.16	-0.67	-1.23	-3.37
Paper & Allied Products	0.75	1.77	1.73	-0.42	-0.27	-1.75
Rubber Products	2.58	2.88	2.90	-0.87	-0.96	-1.00
Plastic Products	5.13	3.52	1.55	-0.84	1.22	-2.85
Primary Metals, Ferrous	1.03	3.08	2.58	-0.99	-2.11	-1.57
Fabricated Metal Products	1.35	3.46	1.55	-0.87	-1.24	-1.23
Motor Vehicles & Parts	0.90	1.28	2.28	-0.94	-0.16	-1.13
Food	0.61	1.40	0.72	-0.24	0.10	-1.37
Beverages	0.56	1.24	0.61	-0.40	0.13	-0.97
Tobacco Products	-0.99	1.72	0.08	-0.13	-0.20	-2.27
Printing & Publishing	2.24	4.32	0.80	0.00	0.32	-3.04
Non-Metallic Mineral Products	0.62	3.12	0.75	-0.46	-1.35	-1.03
Total	0.99	2.45	1.29	-0.59	-0.46	-1.55

Table 3-2 (Cont d)

	Employment Growth Rate (%)	Sources of Employment Growth (%)				
		Domestic Final Demand	Exports	Import Penetration	Technological Change	Productivity
1981-86						
Other Transportation Equipment	-5.93	-3.03	0.51	-1.01	-0.95	-1.96
Other Electrical & Electronics	-3.79	-0.30	2.07	-1.84	0.04	-3.73
Primary Metals, NonFerrous	-3.51	-0.21	3.60	-0.89	-0.27	-6.47
Textiles	-1.82	1.77	1.22	-2.24	0.80	-3.27
Paper & Allied Products	-1.45	0.98	1.53	-0.59	0.12	-3.48
Rubber Products	-0.64	-0.15	5.11	-1.77	0.16	-3.05
Plastic Products	4.15	0.77	3.13	-0.46	2.19	-2.11
Primary Metals, Ferrous	-3.88	-0.75	1.79	0.65	-2.00	-2.39
Fabricated Metal Products	-1.18	-0.02	2.07	-0.49	-1.47	-1.91
Motor Vehicles & Parts	5.34	0.32	10.96	-0.81	0.35	-6.23
Food	-0.23	0.80	0.64	-0.37	0.01	-1.60
Beverages	-0.61	0.98	-0.43	-0.29	0.24	-1.38
Tobacco Products	-4.24	-3.87	-0.75	0.16	0.04	-0.53
Printing & Publishing	2.19	1.60	1.35	-0.36	0.10	-0.93
Non-Metallic Mineral Products	-0.88	0.26	1.33	-0.50	-0.11	-2.43
Total	-0.37	0.41	2.64	-0.67	-0.16	-2.85
1986-91						
Other Transportation Equipment	-1.47	1.99	-0.88	-0.19	-0.51	-3.20
Other Electrical & Electronics	-2.78	2.51	1.87	-5.30	0.97	-0.84
Primary Metals, Non-Ferrous	-1.71	0.49	3.18	-1.38	0.05	-3.31
Textiles	-2.23	-0.03	1.78	-3.52	0.60	-0.14
Paper & Allied Products	-1.27	0.69	1.74	-1.41	0.27	-1.10
Rubber Products	-2.32	0.85	1.30	-4.98	0.76	-0.09
Plastic Products	4.18	0.76	1.24	-2.76	0.68	1.43
Primary Metals, Ferrous	-2.65	0.65	0.87	-1.07	1.47	-1.86
Fabricated Metal Products	0.71	0.92	0.04	-1.73	0.60	1.26
Motor Vehicles& Parts	-1.16	0.20	-1.40	1.35	0.08	-1.78
Food	-0.31	0.98	0.65	-1.06	0.23	-1.02
Beverages	-6.11	0.27	1.03	-1.57	0.02	-4.63
Tobacco Products	-7.20	-2.21	1.45	-2.93	-0.01	-4.05
Printing & Publishing	1.56	2.42	0.24	-1.68	-1.21	2.04
Non-metallic Mineral Products	-1.59	0.91	0.12	-2.03	-1.08	1.60
Total	-0.70	0.98	0.59	-1.52	0.16	-0.46

Plastic products and the printing and publishing industries are the only medium-knowledge manufacturing industries that made the list of top 20 employment growth industries over the period 1971-91. These industries benefited mainly from domestic market expansion, though exports also played a role (Table 3-2).

There has been much concern over employment losses in such medium-knowledge industries as textiles and steel (primary metals, ferrous). Our results show that changing production techniques (in the steel industry) and imports (in the textile industry) have been the major factors responsible for employment declines in those industries.

Low-Knowledge Industries

The results are very different for low-knowledge manufacturing industries. Over the 1971-81 period, most of these industries recorded positive employment growth. This progress was predominantly driven by changes in domestic demand, but exports also played a role. However, employment in these industries declined at a much faster pace during the period 1986-91 as import penetration dealt a particularly hard blow to employment growth during that period (Chart 3-5).

The impact of import penetration has been particularly severe on employment in other manufacturing industries such as furniture and fixtures and leather. For example, the leather industry shed 54 per cent of its employed labour force between 1971 and 1991 (Table 3-3).

Chart 3-5
Sources of Employment Growth in the Low-Knowledge Manufacturing Sector, 1971-91

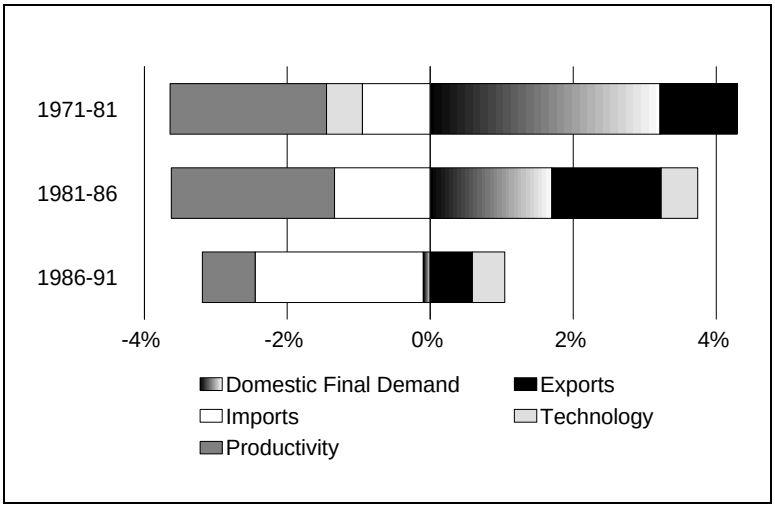


Table 3-3
Sources of Employment Growth in Low-Knowledge Manufacturing Industries, Selected Periods, 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	**Domestic Final Demand**	**Exports**	**Import Penetration**	**Technological Change**	**Productivity**
1971-81						
Other Manufacturing Products	0.28	4.15	1.28	-1.16	-0.72	-2.50
Wood	1.98	2.15	2.39	-0.47	-0.93	-1.66
Furniture & Fixtures	2.01	4.05	1.03	-0.95	-0.10	-1.27
Clothing	-0.62	3.58	0.10	-1.15	-0.23	-2.90
Leather	-0.83	2.81	0.26	-1.57	-0.37	-2.24
Total	0.62	3.21	1.08	-0.95	-0.50	-2.19
1981-86						
Other Manufacturing Products	0.07	2.31	1.93	-1.40	0.43	-1.15
Wood	-0.34	0.70	2.37	0.14	0.83	-4.32
Furniture & Fixtures	2.47	0.13	2.18	-0.27	0.44	-0.64
Clothing	0.07	3.16	0.41	-2.68	0.35	-1.71
Leather	-3.14	1.68	0.80	-3.90	0.17	-1.17
Total	0.06	1.70	1.53	-1.34	0.51	-2.28
1986-91						
Other Manufacturing Products	0.99	0.83	1.37	-3.32	0.73	1.12
Wood	-1.93	-0.31	0.22	-0.66	0.72	-1.97
Furniture & Fixtures	-1.83	1.95	0.16	-4.39	0.37	1.84
Clothing	-3.84	-1.07	0.84	-1.89	0.10	-1.64
Leather	-9.94	-1.64	0.47	-6.20	0.42	-0.86
Total	-2.55	-0.10	0.59	-2.35	0.45	-0.74

Technology-Intensive Manufacturing

High-Technology Industries

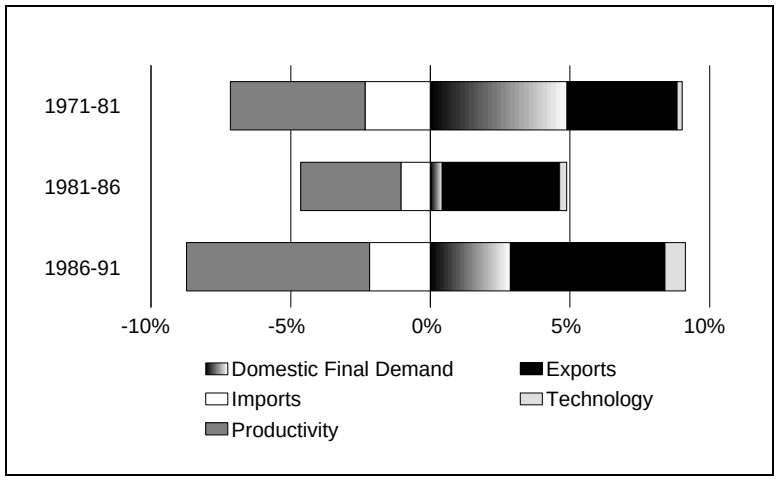
In high-technology industries, exports and domestic final demand contributed most to employment growth, with exports becoming the dominant factor in the 1980s (Chart 3-6). While technological change played a positive role in most of these industries, it was more than offset by their import demands. The net effect of trade on employment growth was strongest in industries such as computers and office equipment, communications equipment, and aircraft manufacturing (Table 3-4).

Table 3-4
Sources of Employment Growth in High-Technology Manufacturing Industries, Selected Periods, 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	Domestic Final Demand	Exports	Import Penetration	Technological Change	Productivity
1971-81						
Pharmaceuticals	1.37	4.22	0.65	-0.62	1.08	-2.94
Computers & Office Equipment	6.39	15.47	18.21	-13.35	2.54	-18.68
Electrical Equipment & Appliances	1.00	4.45	1.37	-1.43	-1.13	-2.27
Communications Equipment & Components	-0.55	5.17	4.38	-3.78	0.84	-8.07
Aircraft Manufacturing	5.04	2.37	6.05	1.22	0.25	-3.77
Scientific & Photographic Equipment	3.53	3.91	2.15	-1.85	0.55	0.04
1981-86						
Pharmaceuticals	1.29	4.00	0.24	-0.28	-0.83	-3.63
Computers & Office Equipment	0.57	4.04	27.01	-3.25	0.78	-19.04
Electrical Equipment & Appliances	-3.51	-0.85	1.95	-2.07	0.05	-2.49
Communications Equipment & Components	1.47	0.81	4.56	-0.73	0.95	-5.22
Aircraft Manufacturing	-0.12	-1.51	0.05	0.71	0.18	2.69
Scientific & Photographic Equipment	1.29	1.04	2.53	-1.03	-0.26	-1.90

1986-91						
Pharmaceuticals	4.31	4.07	0.48	-0.66	0.10	0.51
Computers & Office Equipment	-1.68	2.04	18.89	-1.25	0.40	-23.13
Electrical Equipment & Appliances	-1.83	3.03	2.05	-5.41	1.12	-1.08
Communications Equipment & Components	1.82	4.28	7.59	-0.74	0.64	-11.99
Aircraft Manufacturing	2.11	1.08	4.82	-0.14	0.63	-5.04
Scientific & Photographic Equipment	-1.64	1.73	4.48	-3.74	1.01	-2.44

Chart 3-6
Sources of Employment Growth in High-Technology Manufacturing Industries, 1971-91



Medium-Technology Industries

Between 1971 and 1981, employment growth in medium-technology manufacturing industries was mainly due to strong expansion of the domestic market. During the 1980s, exports tended to compensate the adverse effects of imports and productivity on labour demand. In addition, changes in production techniques also began to contribute to employment growth in the 1980s (Chart 3-7). However, increasing import penetration over the latter part of the decade adversely affected employment in areas such as chemicals, rubber and plastics, and others (Table 3-5).

Chart 3-7
Sources of Employment Growth in Medium-Technology Manufacturing Industries, 1971-91

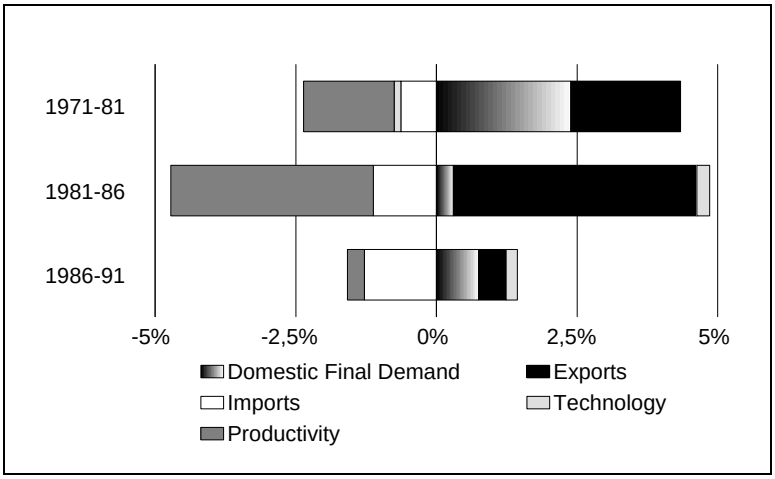


Table 3-5
Sources of Employment Growth in Medium-Technology anufacturing Industries, Selected Periods, 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	**Domestic Final Demand**	**Exports**	**Import Penetration**	**Technological Change**	**Productivity**
1971-81						
Chemicals	1.33	2.85	2.07	-0.01	0.40	-4.02
Rubber & Plastics	3.93	3.22	2.18	-0.85	0.20	-1.98
Non-Ferrous Metals	0.72	1.25	0.90	-0.59	-0.19	-0.31
Non-Electrical Machinery & Components	3.12	2.96	2.53	-0.49	-0.40	-1.23
Other Transportation Equipment	0.69	1.33	-0.26	-0.35	0.22	2.02
Motor Vehicles & Parts	0.90	1.28	2.28	-0.94	-0.16	-1.13
Other Manufacturing	0.59	4.30	1.28	-1.07	-0.62	-2.45
1981-86						
Chemicals	-0.93	0.96	2.17	-0.92	0.01	-3.23
Rubber & Plastics	2.15	0.39	3.95	-1.00	1.34	-2.50
Non-Ferrous Metals	-3.51	-0.21	3.60	-0.89	-0.27	-6.47
Non-Electrical Machinery & Components	-2.72	-0.43	-0.01	-1.48	-0.19	-1.52
Other Transportation Equipment	-3.07	-2.35	0.98	-2.98	-0.40	-1.05
Motor Vehicles & Parts	5.34	0.32	10.96	-0.81	0.35	-6.23
Other Manufacturing	0.58	2.35	1.72	-1.33	0.50	-1.03
1986-91						

Chemicals	-0.28	1.34	2.07	-3.23	-0.11	0.29
Rubber & Plastics	1.88	0.79	1.26	-3.54	0.71	0.89
Non-Ferrous Metals	-1.71	0.49	3.18	-1.38	0.05	-3.31
Non-Electrical Machinery & Components	0.37	1.34	0.16	-1.24	-0.01	1.35
Other Transportation Equipment	-2.72	-0.33	-0.18	-1.30	0.47	-1.21
Motor Vehicles & Parts	-1.16	0.20	-1.40	1.35	0.08	-1.78
Other Manufacturing	1.02	0.81	1.51	-3.41	0.77	1.11

Low-Technology Industries

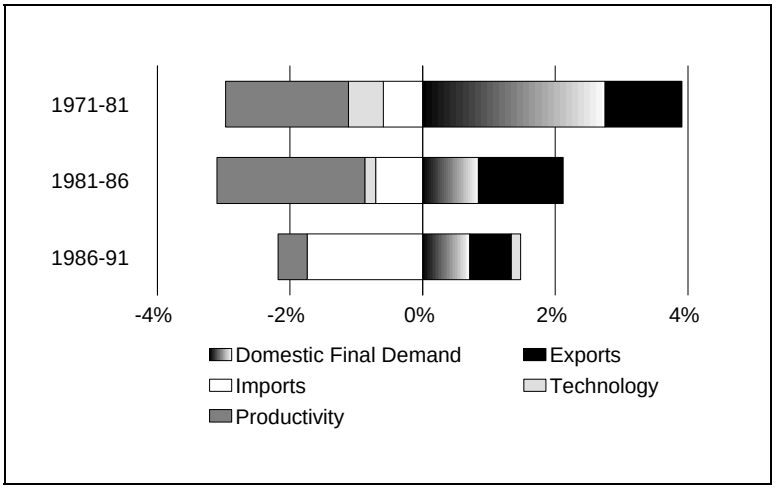
In low-technology manufacturing industries, the contribution of final domestic demand and exports to employment growth declined during the 1980s. In addition, restructuring, as evidenced by rising labour productivity, also contributed to employment adjustment in these industries. In the latter period, however, import penetration began to play a more important role (Chart 3-8). This effect was more pronounced in industries such as textiles, clothing and footwear, wood and wood products, and non-metallic mineral products (Table 3-6).

Table 3-6
Sources of Employment Growth in Low-Technology Manufacturing Industries, Selected Periods, 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	Domestic Final Demand	Exports	Import Penetration	Technological Change	Productivity
1971-81						
Food, Beverages & Tobacco	0.54	1.39	0.68	-0.26	0.10	-1.35
Textiles, Clothing & Footwear	-0.68	3.40	0.47	-1.07	-0.59	-2.96
Wood, Wood Products & Furniture	1.84	2.73	1.91	-0.63	-0.70	-1.49
Paper, Paper Products & Printing	1.43	2.91	1.31	-0.23	0.01	-2.32
Petroleum Refining & Products	3.98	2.41	1.10	0.52	-0.79	0.15
Non-Metallic Mineral Products	0.62	3.12	0.75	-0.46	-1.35	-1.03
Iron & Steel	1.03	3.08	2.58	-0.99	-2.11	-1.57
Fabricated Metal Products	1.62	3.46	1.56	-0.84	-1.12	-1.37
Shipbuilding & Repair	2.28	3.24	0.64	-1.51	0.45	-1.17
1981-86						
Food, Beverages & Tobacco	-0.41	0.66	0.45	-0.34	0.04	-1.53
Textiles, Clothing & Footwear	-1.02	2.52	0.77	-2.69	0.45	-2.14

Wood, Wood Products & Furniture	0.17	0.41	2.23	-0.01	0.72	-3.29
Paper, Paper Products & Printing	0.28	1.28	1.44	-0.48	0.11	-2.25
Petroleum Refining & Products	-6.90	-0.76	1.31	-1.51	-1.09	-4.10
Non-Metallic Mineral Products	-0.88	0.26	1.33	-0.50	-0.11	-2.43
Iron & Steel	-3.88	-0.75	1.79	0.65	-2.00	-2.39
Fabricated Metal Products	-1.23	0.14	1.94	-0.45	-1.57	-1.93
Shipbuilding & Repair	-9.10	-3.79	-0.01	1.15	-1.56	-2.96
1986-91						
Food, Beverages & Tobacco	-1.21	0.81	0.72	-1.17	0.20	-1.55
Textiles, Clothing & Footwear	-3.94	-0.79	1.06	-2.83	0.28	-1.06
Wood, Wood Products & Furniture	-1.98	0.16	0.45	-1.90	0.64	-0.98
Paper, Paper Products & Printing	0.29	1.61	0.95	-1.55	-0.53	0.60
Petroleum Refining & Products	-2.28	0.74	1.75	-1.14	-0.35	-2.68
Non-Metallic Mineral Products	-1.59	0.91	0.12	-2.03	-1.08	1.60
Iron & Steel	-2.65	0.65	0.87	-1.07	1.47	-1.86
Fabricated Metal Products	-0.16	1.16	-0.25	-1.80	0.58	1.32
Shipbuilding & Repair	0.12	5.05	-1.81	1.25	-1.78	-5.86

Chart 3-8
Sources of Employment Growth in Low-Technology Manufacturing Industries, 1971-91



The shipbuilding industry presents an interesting case. Employment in this industry has been in decline throughout the OECD, falling by around 50 per cent since 1970. This has largely been in response to excess capacity. In Canada, vigorous expansion in domestic demand during the 1970s led to strong employment growth. In the early 1980s, however, the industry shed about 38 per cent of its work force. While technological change and restructuring played important adverse roles, domestic demand was the most important factor contributing to the decline. During the latter part of the 1980s, employment gains due to the rise in domestic demand were offset by the strong rise in productivity (Table 3-6).

Other Classifications of Manufacturing Industries

Table 3-7 shows sources of employment growth for various other manufacturing groups – high-, medium-, and low-wage; natural-resource intensive, labour-intensive, product-differentiated, scale-intensive, and science-based; and high- and low-skill. In general, familiar messages emerge over time about the declining importance of domestic demand and the rising importance of trade. Exports were a key contributor to employment growth in high-wage, science-based, and scale-intensive manufacturing industries. The negative contribution of import penetration was concentrated in low-wage, labour-intensive, and product-differentiated sectors. Finally, labour-saving productivity increases were particularly evident in high-wage, science-based, and high-skill industries.

The Service Sector

In the service sector, the domestic market was the dominant force driving employment growth over the 1971-91 period (Chart 3-9). In part, this reflects the fact that services are generally less traded than goods, although this began to change during the 1980s. While exports

Table 3-7

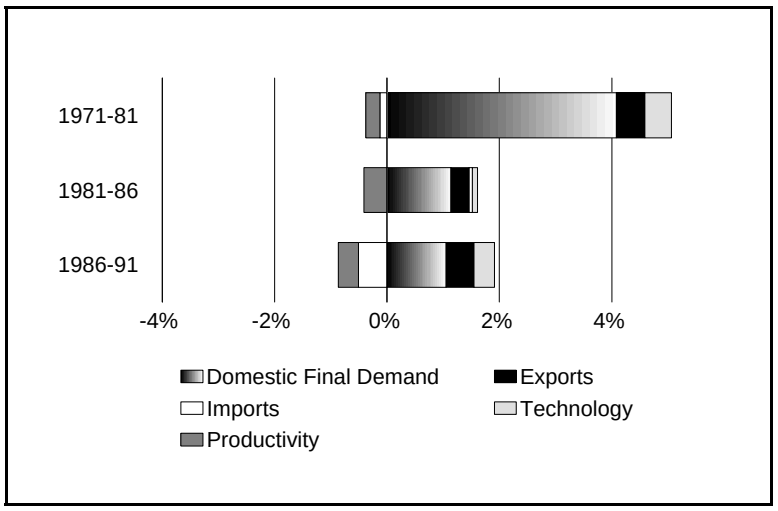
Sources of Employment Growth in Various Manufacturing Groups,[1] 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	Domestic Final Demand	Exports	Imports	Technological Change	Productivity
WAGE LEVEL						
1971-81						
High	2.00	2.73	3.22	-0.88	0.19	-3.03
Medium	1.64	3.14	1.83	-0.83	-0.46	-1.99
Low	0.47	2.70	0.93	-0.73	-0.42	-1.94
1981-86						
High	1.76	0.58	7.04	-0.79	0.10	-4.76
Medium	-0.96	0.33	1.88	-0.58	-0.34	-2.57
Low	-0.72	1.05	1.14	-1.21	0.32	-2.12
1986-91						
High	-0.29	0.93	1.55	-0.25	0.11	-2.80
Medium	-0.03	1.46	1.23	-1.67	0.09	-0.49
Low	-2.05	0.38	0.89	-2.28	0.44	-1.06

SECTOR ORIENTATION						
1971-81						
Natural Resource-Intensive	1.06	1.98	1.07	-0.39	-0.35	-1.20
Labour-Intensive	0.27	3.50	0.94	-0.99	-0.78	-2.33
Product-Differentiated	1.60	3.93	2.62	-1.56	-0.32	-3.18
Scale-Intensive	1.49	2.58	1.78	-0.54	-0.20	-2.01
Science-Based	4.12	5.10	5.77	-2.15	0.83	-4.81
1981-86						
Natural Resource-Intensive	-0.83	0.41	1.41	-0.36	0.16	-2.72
Labour-Intensive	-0.92	1.60	1.32	-1.69	-0.31	-1.94
Product-Differentiated	-1.98	-0.26	1.58	-1.47	0.14	-2.64
Scale-Intensive	0.67	0.50	3.86	-0.56	-0.01	-3.26
Science-Based	0.58	1.05	5.50	-0.58	0.01	-3.40
1986-91						
Natural Resource-Intensive	-1.57	0.59	0.82	-1.51	0.17	-1.23
Labour-Intensive	-1.86	0.17	0.61	-2.51	0.46	0.13
Product-Differentiated	0.19	2.54	2.59	-2.16	0.44	-2.76
Scale-Intensive	-0.28	1.07	0.46	-1.16	-0.01	-0.36
Science-Based	1.04	1.96	6.30	-1.24	0.58	-6.46
SKILL LEVEL						
1971-81						
High	1.39	2.91	1.85	-0.72	-0.02	-2.56
Low	1.07	2.89	1.50	-0.87	-0.63	-1.73
1981-86						
High	-0.34	0.79	1.94	-0.52	-0.20	-2.42
Low	-0.51	0.53	2.84	-1.16	0.16	-3.04
1986-91						
High	-0.09	1.49	1.83	-1.53	0.10	-1.56
Low	-1.52	0.49	0.55	-1.78	0.34	-0.70

1 Based on a 33-industry classification.

Chart 3-9
Sources of Employment Growth in the Service Sector, 1971-91



began to fuel employment growth in this sector at that time, import penetration began to dominate in the latter part of the decade. At the same time, technological change and productivity growth started playing more important roles. While labour productivity gains affected employment growth negatively (given the mechanical nature of the relationship), they had a much smaller impact in the service sector than that observed in the manufacturing sector.

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 I/O 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 in Canada contains about 38 cents' worth of service sector output.

High-Knowledge Services

In high-knowledge services, employment growth has been led by the expansion of domestic demand. This is not surprising, given that high-knowledge services are dominated by non-market service industries (educational services, health and social services). However, in business services, which lead the growth rankings in this group of industries, technological change also made significant contributions to employment growth. The business services sector is a heavy user of technology, with a large proportion of skilled workers (Table 3-8).

Although labour productivity increases partly offset the increase in employment in business services, the effect of export expansion almost compensated for this adverse effect. Employment growth in education and in health and social services was supported by the absence of labour productivity improvements.

Table 3-8
Sources of Employment Growth in High-Knowledge Services,[1] 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	Domestic Final Demand	Exports	Imports	Technological Change	Productivity
1971-81						
SERVICES						
Business Services	7.38	4.35	1.23	-0.44	3.52	-1.46
Educational Services	4.74	4.07	0.10	0.10	-0.01	0.70
Health & Social Services	5.68	5.72	0.01	-0.08	0	0.13
Total	6.93	4.62	0.94	-0.34	2.67	-1.05
UTILITIES						
Electric Power Systems	3.82	4.53	1.34	-0.10	0.53	-2.75
Pipeline Transport	6.20	1.71	-0.77	0.67	1.01	3.36
Total	3.96	4.36	1.22	-0.05	0.56	-2.39
1981-86						

SERVICES						
Business Services	4.14	1.83	1.17	1.46	0.13	-1.31
Educational Services	3.86	2.24	0.13	-0.06	-0.01	-0.99
Health & Social Services	5.01	3.80	0	0	0	1.69
Total	4.30	2.23	0.91	1.12	0.10	-0.70
UTILITIES						
Electric Power Systems	0	1.96	0.58	-0.10	0.65	-2.88
Pipeline Transport	2.33	2.06	1.27	0.28	-0.18	0.07
Total	0.16	2.18	0.69	-0.09	0.66	-2.99
1986-91						
SERVICES						
Business Services	4.88	2.55	1.19	-0.82	2.54	-0.92
Educational Services	8.43	4.32	0.97	-1.18	0	4.90
Health & Social Services	5.30	3.97	0.01	-0.41	0.01	1.40
Total	5.09	2.90	0.94	-0.75	1.94	-0.25
UTILITIES						
Electric Power Systems	1.00	2.10	0.10	-0.62	1.28	-1.82
Pipeline Transport	0.33	1.73	5.19	-0.27	0.59	-6.03
Total	0.95	2.08	0.48	-0.60	1.23	-2.13

1 Based on a 55-industry disaggregation.

In the case of utilities, electric power systems and pipeline transport services deserve mention for their strong employment growth rates throughout the 1970s and early 1980s. The main factor here was domestic demand, although exports made significant and growing contributions (Table 3-8). Finally, slow employment growth in the pipeline transport industries during the 1986-91 period was mainly due to large productivity gains.

Medium-Knowledge Services

Between 1971 and 1991, all four medium-knowledge services sectors – wholesale trade; finance, insurance, and real estate; services incidental to mining; and recreation services –

Table 3-9
Sources of Employment Growth in Medium-Knowledge Services,[1] 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	**Domestic Final Demand**	**Exports**	**Imports**	**Technoloical Change**	**Productivity**
1971-81						
SERVICES						
Wholesale Trade	3.40	4.42	0.84	-0.20	-0.49	-1.36
Finance, Real Estate & Insurance	5.02	4.67	0.44	-0.17	0.98	-1.27
Services Incidental to Mining	7.93	5.96	0.08	0.12	6.77	-5.25
Recreation Services	5.06	6.92	0.11	-0.25	0.24	-1.74

Total	4.38	4.73	0.59	-0.18	0.44	-1.46
UTILITIES						
Telecommunications	3.39	6.75	0.76	-0.21	3.42	-7.25
Gas Distribution Systems	3.76	3.92	0.46	-0.09	-0.14	-0.29
Total	3.42	6.53	0.74	-0.20	3.13	-6.69
1981-86						
SERVICES						
Wholesale Trade	2.81	1.71	1.45	-0.17	0.35	-1.88
Finance, Real Estate & Insurance	2.54	2.42	0.72	-0.11	0.84	-1.52
Services Incidental to Mining	-1.34	-6.02	0.98	-0.05	0.89	2.24
Recreation Services	8.95	4.27	0.18	0.31	0.65	4.25
Total	2.99	1.97	1.00	-0.11	0.62	-1.13
UTILITIES						
Telecommunications	-0.76	3.21	0.80	-0.05	0.13	-4.32
Gas Distribution Systems	2.06	1.34	0.66	-0.10	-0.84	0.83
Total	-0.52	3.04	0.79	-0.05	0.05	-3.88
1986-91						
SERVICES						
Wholesale Trade	2.48	2.81	0.99	-0.52	1.28	-1.03
Finance, Real Estate & Insurance	2.74	3.02	0.65	-0.88	0.26	-0.33
Services Incidental to Mining	0.21	2.70	1.42	-0.50	-5.29	1.37
Recreation Services	0.58	1.16	2.44	-2.42	-0.12	-1.36
Total	2.38	2.77	0.96	-0.84	0.51	-0.66
UTILITIES						
Telecommunications	1.19	4.45	0.91	-0.96	2.45	-5.32
Gas Distribution Systems	-1.51	0.76	0.88	-0.46	-0.66	-3.37
Total	0.96	4.13	0.90	-0.92	2.17	-5.15

1 Based on a 55-industry disaggregation.

recorded high employment growth rates. Employment in these industries rose at average annual rate of 3.6 per cent, nearly two thirds faster than that experienced in the Canadian business sector as a whole over the same period. Again, domestic demand was the major engine of employment growth. Export expansion and changes in technology also contributed to employment growth in the 1980s, though to a lesser extent than domestic demand.

The large positive effect of changes in input/output coefficients and the negative contribution of labour productivity growth in services incidental to mining were particularly

pronounced in the 1971-81 period. As mentioned at the beginning of the chapter, the various factors of the decomposition analysis may not be independant of each other. Thus, in the context of this model, although technology affects productivity, it is very difficult to separate the direct and indirect effects of technology from those of productivity and other factors such as trade (Table 3-9).

In medium-knowledge utilities, the high employment growth rates attained by both telecommunications and gas distribution systems were mainly due to growth in domestic demand. Changes in input/output coefficients also had a significant impact on employment growth in the telecommunications industry. However, such gains were partly offset by the negative contribution from strong labour productivity improvements. Exports also made noticeable contributions throughout the period, while the effect of import penetration, which was virtually non-existent until then, began to emerge during the second half of the decade (Table 3-10).

Low-Knowledge Services

Among low-knowledge services, traditional services such as personal services, accommodation and food services, retail trade, and other services enjoyed strong employment growth rates between 1971 and 1991. Again, this was due principally to growth in domestic final demand. While the impact of trade was minimal during the first two sample periods, in the 1986-91 period the effect of both exports and imports on employment increased in storage and warehousing, accommodation and food services, and other services. Changes in production techniques also made positive contributions to employment during this period, except in storage and warehousing services (Table 3-10).

The Natural Resource Sector

While the Canadian economy is generally considered to be natural resource-oriented, this sector accounted for less than 10 per cent of the economy's gross output and only 7 per cent of total employment in 1991. The natural resource sector is predominantly a medium- to low-knowledge sector.

In net terms, medium-knowledge industries in this sector lost employment during the 1980s despite strong export performance, as labour productivity increases partly offset the increase in employment. Mineral fuels attained the highest rate of employment growth, mainly

Table Table 3-10
Sources of Employment Growth in Low-Knowledge Services,[1] 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	Domestic Final Demand	Exports	Imports	Technological Change	Productivity
1971-81						
Transportation Services	2.37	2.83	1.50	-0.22	0.01	-1.76
Storage & Warehousing	2.38	2.48	1.20	-0.14	-1.14	0.35
Retail Trade	3.88	3.70	0.15	-0.05	-0.16	0.50
Personal Services	5.79	4.02	0.34	0.03	1.00	-0.17
Accommodation & Food Services	6.96	4.48	0.12	-0.04	0.10	2.24
Other Services	4.62	2.68	0.45	-0.17	0.52	1.08
Total	4.42	3.71	0.40	-0.07	0.04	0.41
1981-86						
Transportation Services	-1.09	1.04	1.48	-0.07	0.31	-3.70
Storage & Warehousing	-1.81	1.00	0.20	-0.10	-1.07	-3.14
Retail Trade	0.98	3.22	0.24	-0.03	-0.01	-2.29
Personal Services	6.04	4.68	0.55	0.12	0.08	2.83
Accommodation & Food Services	3.33	0.64	0.16	-0.02	-0.34	2.86
Other Services	1.74	1.06	0.76	-0.12	2.49	-2.45
Total	1.81	2.45	0.44	-0.02	0	-0.73
1986-91						
Transportation Services	-0.14	0.79	1.41	-1.44	0.80	-1.32
Storage & Warehousing	2.76	0.74	2.92	-0.46	-3.55	2.87
Retail Trade	0.89	1.78	0.25	-0.21	0.13	-0.74
Personal Services	3.52	3.02	0.60	-0.55	1.11	-2.40
Accommodation & Food Services	1.22	0.81	2.56	-3.27	0.66	-0.15
Other Services	0.71	0.99	1.80	-2.84	1.07	-0.20
Total	1.21	1.58	1.03	-1.18	0.47	-0.87

1 Based on a 55-industry disaggregation.

as a result of strong export performance in the 1980s. While the absence of labour productivity growth supported employment growth in this sector during the 1971-81 period, strong productivity improvements led to significant employment losses during the 1980s, especially in metal mines and non-metal mines (Table 3-11).

Among low-knowledge primary industries, fishing and trapping recorded the strongest employment growth rate over the 1971-91 period. This was mainly the result of rapid growth in exports. The absence of labour productivity improvements was also a dominant factor during the 1970s.

Table 3-11
Sources of Employment Growth in the Natural Resource Sector,[1] 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	**Domestic Final Demand**	**Exports**	**Imports**	**Technological Change**	**Productivity**
MEDIUM-KNOWLEDGE						
1971-81						
Metal Mines	-0.40	0.52	0.99	-0.85	-0.49	-0.33
Non-Metal Mines	1.64	0.94	2.10	0.09	-0.40	-2.53
Mineral Fuels	6.51	1.76	-1.99	1.79	-0.82	5.64
Total	1.51	0.87	0.58	-0.08	-0.54	0.50
1981-86						
Metal Mines	-6.75	-0.03	1.37	0.39	-0.49	-8.46
Non-Metal Mines	-4.00	0.13	1.10	-0.45	-0.36	-5.00
Mineral Fuels	3.92	-0.09	5.14	-0.12	-0.90	0.49
Total	-2.80	-0.02	2.50	0.06	-0.59	-4.90
1986-91						
Metal Mines	-2.40	0.32	1.93	-0.28	-0.71	-4.48
Non-Metal Mines	-1.36	0.48	1.32	0.91	-0.11	-3.79
Mineral Fuels	-1.31	0.69	4.75	-2.21	0.06	-4.84
Total	-1.77	0.49	2.90	-0.79	-0.30	-4.48
LOW-KNOWLEDGE						
1971-81						
Fishing & Trapping	5.73	0.44	3.02	-0.58	-0.44	3.12
Forestry	0.22	1.54	2.38	-0.37	-1.26	-2.47
Agriculture	-0.03	1.71	0.95	-0.34	-0.30	-2.22
Quarries & Sand Pits	0.42	2.56	0.24	-0.06	0.26	-0.88
Total	0.25	1.65	1.18	-0.35	-0.40	-1.99
1981-86						

Fishing & Trapping	0.87	0.59	4.18	-0.81	-1.65	-1.50
Forestry	-2.95	0.91	2.32	-0.13	0.49	-7.14
Agriculture	-0.38	1.14	0.34	-0.17	-0.31	-1.68
Quarries & Sand Pits	3.33	0.45	0.37	0.70	0.86	-3.89
Total	-0.50	1.07	0.76	-0.19	-0.30	-2.23
1986-91						
Fishing & Trapping	3.60	1.65	0.13	1.69	0.93	-0.01
Forestry	0.34	0.31	0.13	-0.79	-0.04	-0.74
Agriculture	-1.62	-0.24	1.83	-0.57	0.09	-2.31
Quarries & Sand Pits	-1.64	0.05	0.68	-1.55	-0.04	4.05
Total	-1.08	-0.05	1.54	-0.45	0.14	-1.91

1 Based on a 55-industry disaggregation.

Table 3-12
Sources of Employment Growth in the Construction Industry, 1971-91

		Sources of Employment Growth (%)				
	Employment Growth Rate (%)	Domestic Final Demand	Exports	Imports	Technological Change	Productivity
1971-81	2.21	3.45	0.09	0	-0.14	-1.17
1981-86	-0.63	0.48	0.17	-0.03	-0.35	-0.88
1986-91	2.64	1.99	0.15	-0.12	-0.05	0.70

The Construction Sector

Employment in the construction industry – a medium-knowledge sector – increased by 202,000 in the period 1971-91. Not surprisingly, domestic demand was the principal contributor to this development. The 1981-82 recession had a strong negative impact on employment growth in the 1981-86 period. In the subsequent period, however, low productivity growth contributed to employment growth (Table 3-12).

Summary

While domestic demand and labour productivity growth have always been important determinants of employment growth, our decomposition analysis has shown that trade and technology played a growing role during the 1980s and early 1990s. Exports have become a dominant factor in employment growth, particularly in high-knowledge, high-technology, and high-wage manufacturing industries. Conversely, import penetration has adversely affected

employment growth in low-knowledge, low-technology, low-wage, low-skill, and labour-intensive industries.

The importance of trade and technology is increasing in the Canadian service sector, particularly in high- and medium-knowledge areas such as business services and finance, insurance, and real estate.

While our decomposition analysis enabled us to calculate the contributions of labour productivity, changing production techniques, and foreign trade to employment growth over 1971-91 period, a number of additional observations are warranted.

Productivity and Employment

The productivity/employment relationship that we observe in our model is mechanical in nature – i.e., it does not take into account the dynamic effects resulting from lower prices and income gains. Consequently, productivity is always labour-saving in this type of analysis.

Chart 3-10
Productivity and Employment Growth in the Manufacturing Sector, 1971-91

However, when we examine the relationship between employment and productivity in greater detail, we find that those industries which registered the fastest productivity growth also recorded the fasted employment growth.

Chart 3-10 shows that a positive relationship existed between employment and labour productivity growth in the Canadian manufacturing sector over the 1971-91 period.[16] According to our results, high-technology industries had above-average productivity gains (with an average

annual growth rate of 4.46 percent compared to 2.0 per cent for manufacturing overall), but they also had better-than-average employment growth (0.8 per cent compared to 0.3 percent for manufacturing as a whole). In contrast, low-technology industries had below-average productivity (1.62 per cent per year) and employment growth (-0.14 per cent per year).

Technology and Employment

Changes in I/O coefficients essentially represent changes in production techniques, which we have loosely interpreted as technological change. Our finding that the importance of technology as a source of employment growth is increasing is based on this crude indicator. However, the evidence on the relationship between employment and R&D intensity and other more reliable indicators of innovation in the G-7 countries suggests that those manufacturing industries with the highest rates of R&D and innovation experienced greater output and employment growth (Pianta et al., 1995; OECD, 1996). In services, we have seen that information technology-intensive industries such as finance and business services and wholesale trade recorded strong employment gains.

Trade and Employment

Our analysis showed that trade emerged of as a major determinant of changes in employment, with some industries or sectors gaining and others losing. This is consistent with the international evidence, which shows that international trade has led to significant job losses in traditional manufacturing industries, especially in labour-intensive activities such as textiles, clothing, wood, furniture, and leather (Driver, Kilpatrick & Naisbitt, 1988; Wood, 1994; Revenga, 1992; Grossman 1984, 1987).[17]

However, an important policy question is, What is the net impact of trade on employment?[18] The OECD (1994) found that the net employment effects of changes in exports and imports in OECD countries have been small. At the same time, our results show that trade had significant impact on employment growth in Canada over the period 1971-91. While the net impact was positive over the 1971-81 and 1981-86 periods (0.53 and 0.9 per cent annually, respectively), the net impact was slightly negative in the second half of the 1980s.

Table 3-13 shows the number of jobs created as a result of exports and lost due to imports, and the resulting net effect. Three facts stand out. First, a large and growing share of the Canadian labour force depends on exports for jobs: new jobs resulting from the expansion of exports in the business sector increased by 1.4 million between 1971 and 1991. Second, increasing import penetration displaced 715,000 jobs over the same period. Third, the net impact

Table 3-13
Impact of Trade on Employment,[1] by Major Business Sector, 1971-91

	Change in Employment	Change in Employment Due to Change in Exports	Change in Employment Due to Change in Imports	Net Impact of Trade
TOTAL BUSINESS SECTOR				
1971-81	2,107.8	567.9	-209.3	358.6
1981-86	488.3	425.5	-56.8	368.7
1986-91	557.8	440.3	-448.9	-8.6
MANUFACTURING SECTOR				
1971-81	210.4	287.8	-137.9	149.9
1981-86	-39.1	221.1	-78.8	142.3
1986-91	-74.3	103.1	-147.6	-44.5
SERVICE SECTOR (INCLUDING UTILITIES)				
1971-81	1707.5	198.0	-49.6	148.4
1981-86	582.1	160.3	28.4	188.7
1986-91	578.1	270.7	-279.2	-8.5
NATURAL RESOURCE INDUSTRIES (INCLUDING MINING SERVICES)				
1971-81	51.9	76.4	-21.6	54.8
1981-86	-32.8	38.2	-5.6	32.6
1986-91	-39.5	61.3	-17.9	43.4

1 All figures are in thousands.

Table 3-14
Impact of Trade on Manufacturing Employment,[1] 1971-91

	Change in Employment	Change in Employment Due to Change in Exports	Change in Employment Due to Change in Imports	Net Impact of Trade
KNOWLEDGE INTENSITY				
High				
1971-81	79.4	103.4	-32.4	71.0
1981-86	-18.9	41.3	-16.6	24.7
1986-91	8.0	59.9	-22.6	37.3
Medium				
1971-81	114.8	148.9	-67.8	81.1
1981-86	-21.2	152.9	-38.8	114.1
1986-91	-39.8	33.4	-85.8	-52.4
Low				
1971-81	214.9	288.3	-132.0	156.3

	Change in Employment	Change in Employment Due to Change in Exports	Change in Employment Due to Change in Imports	Net Impact of Trade
1981-86	-39.1	221.1	-78.8	142.3
1986-91	-74.3	103.1	-147.6	-44.5
TECHNOLOGY INTENSITY				
High				
1971-81	35.6	76.0	-45.2	30.8
1981-86	-4.3	43.4	-11.0	32.4
1986-91	5.2	57.1	-22.5	34.6
Medium				
1971-81	75.9	83.8	-27.1	56.7
1981-86	13.6	104.8	-27.2	77.6
1986-91	-4.2	12.1	-31.4	-19.3
Low				
1971-81	98.9	128.0	-65.6	62.4
1981-86	-48.4	72.9	-40.6	32.3
1986-91	-75.4	34.0	-93.7	-59.7
WAGE LEVEL				
High				
1971-81	50.9	81.8	-22.4	59.4
1981-86	25.9	103.3	-11.6	91.7
1986-91	-4.4	23.8	-3.8	20.0
Medium				
1971-81	126.3	140.2	-63.7	76.5
1981-86	-39.1	76.8	-23.9	52.9
1986-91	-1.0	49.3	-67.1	-17.8
Low				
1971-81	33.2	65.9	-24.5	41.4
1981-86	-25.9	41.0	-43.3	-2.3
1986-91	-68.9	30.1	-76.7	-46.6
SKILL LEVEL				
High				
1971-81	112.5	150.0	-58.4	91.6
1981-86	-14.6	83.4	-22.4	61.0
1986-91	-4.0	77.8	-65.1	12.7
Low				
1971-81	98.0	137.8	-79.5	58.3
1981-86	-24.6	137.7	-56.4	81.3
1986-91	-70.3	25.3	-82.5	-57.2

1 All figures are in thousands.

of trade has been positive. During that period, 719,000 net new jobs were created as a result of trade, which accounted for about 23 percent of new employment created in Canada. However,

during the second half of the 1980s there was a small net negative effect of trade on employment. Of course, this is largely due to the fact that this period was characterized by an appreciation of the Canadian dollar, a deterioration in cost competitiveness compared to the United States, and the implementation of the Canada-U.S. Free Trade Agreement (Economic Council of Canada, 1992).

On a sectoral level, it is interesting to note that manufacturing trade did not contribute as much to employment as non-manufacturing trade. In addition to the continuing strong export performance of the resource industries, Canada made significant net employment gains due to trade in the services sector (Table 3-13).[19]

Trade was an important element in the restructuring that occurred in the manufacturing sector during the 1980s. Between 1971 and 1991, trade contributed to employment growth in the innovative industries – the high-knowledge, high-technology, science-based, high-skilled, and high-wage manufacturing industries. In contrast, less innovative manufacturing industries, such as medium- and low-knowledge, medium- and low-technology, medium- and low-wage, labour-intensive, natural resource-intensive, scale-intensive, and low-skill manufacturing, registered job losses due to trade. This negative effect on the less innovative industries was especially large in the 1986-91 period (Table 3-14). These findings tend to support the conclusions of a recent study showing that the industries experiencing difficulty in this era of increased global competition are mostly in traditional areas of Canadian manufacturing, while those experiencing growth are in the higher value-added sectors of the economy (Schwanen, 1993).

Table 3-15
Impact of Trade on Employment in Services, by Level of Knowledge, 1971-91

	Change in Employment	Change in Employment Due to Change in Exports	Change in Employment Due to Change in Import Penetration	Net Impact of Trade
HIGH-KNOWLEDGE SERVICES (INCLUDES UTILITIES)				
1971-81	335.1	50.0	-15.7	34.3
1981-86	147.4	33.9	37.8	71.7
1986-91	221.8	42.4	-34.7	7.7
MEDIUM-KNOWLEDGE SERVICES (INCLUDES UTILITIES)				
1971-81	434.4	61.6	-18.9	42.7
1981-86	176.4	68.9	-7.0	75.9
1986-91	171.0	72.8	-64.7	8.1
LOW-KNOWLEDGE SERVICES (NO LOW-KNOWLEDGE UTILITIES)				
1971-81	1 657.9	180.5	-46.4	134.1
1981-86	256.3	62.5	-2.7	59.8
1986-91	185.7	158.1	-180.7	-22.6

1 All figures are in thousands.

Although trade is not as important a factor in services as it is in manufacturing, its effects on employment in that sector have followed a similar pattern. That is, employment in low-knowledge service industries has suffered most from trade, especially over the 1986-91 period (Table 3-15).

4. HOW WELL ARE LABOUR MARKETS ADJUSTING TO THE KNOWLEDGE-BASED ECONOMY?

The evidence presented in the preceding chapters indicates that the Canadian economy is becoming increasingly knowledge-based, and the major factors behind this structural change have increasingly been trade and technology, particularly since the beginning of the 1980s. Associated with this development is the belief that skills and knowledge are becoming more important in determining labour market outcomes. While our evidence indicates that the pace of change has not accelerated, there are growing concerns that, as a result of the shift towards a knowledge-based economy, the gap in earnings and employment opportunities between high- and low-skilled workers has widened, especially in the 1990s.

The main reason behind these concerns is the sharp increase in the demand for high-skilled workers and the decline in that for low-skilled workers observed throughout the industrialized world (OECD, 1994, 1996). It is argued that new technologies, and in particular new information and communication technologies, have increased the skill requirements of both existing and newly created jobs. It is also argued that international trade and the growth of emerging economies have increased the competitive pressures faced by unskilled workers (Freeman, 1995; Wood, 1994, 1995).

Here, we are mainly concerned about how the Canadian labour market has adjusted to the emergence of the knowledge-based economy. Is this development associated with an increase in the demand for high-skilled workers relative to low-skilled workers in Canada? If so, is it reflected in higher returns to skills? We examine recent trends in the skill distribution of employment and earnings. Note, however, that we do not attempt here to analyze the respective roles of trade and technology in these labour market developments.

The Changing Skill Profile of Employment

In this section, skills are proxied by the educational attainment and experience (age) of the workforce or by the type of occupation. Although these measures are common in the literature, they are imperfect because they do not capture all aspects of skills.[20] Education is usually categorized by years of schooling or by the degree obtained, neither of which provides direct information on the quality of education. In addition, education fails to capture an individual's experience or training. In the case of occupations, existing classification systems only provide information on the educational and training requirements of various occupations at a specific point in time; they say nothing about how the skill content of these occupations has evolved over time. Despite these shortcomings, these data do reflect to a large extent the evolution of skills in the economy.

Table 4-1
Occupational Distribution of Employment,[1] Selected Years, 1971-95

Occupational Group	1971	1981	1991	1995
White-Collar	53.4	60.3	67.8	68.3
Blue-Collar	46.6	39.7	32.2	31.7
White-Collar High-Skilled	24.0	27.0	32.8	33.1
White-Collar Low-skilled	29.5	33.3	35.0	35.2
Blue-Collar High-Skilled	15.3	13.1	10.0	9.6
Blue-Collar Low-Skilled	31.3	26.6	22.2	22.1

1 Shares exclude employment in postal services, religious services, and public administration.
Source: Estimates by the authors, based on data from the Canadian Occupational Projection System.

Changes in the Occupational Distribution of Employment

Aggregate Evidence

The increased demand for high-skill workers relative to low-skill workers is revealed by changes in the occupational structure of employment. Table 4-1 depicts these changes by occupation between 1971 and 1995. "Upskilling" is clearly evident, with the share of white-collar employment rising from 53.4 percent in 1971 to 68.3 percent in 1995. In contrast, the share of blue-collar employment fell from 46.6 to 31.7 percent over that period.

The bottom part of Table 4-1 distinguishes between high-skilled and low-skilled jobs within the white-collar and blue-collar occupational groups. This disaggregation is borrowed from OECD (1996), but we use slightly different occupational groups in defining each category.[21] These categories show that between 1971 and 1995 white-collar high-skilled jobs have been underlying employment growth in Canada. These occupations accounted for about two thirds of the increase in the share of white-collar occupations.

Sectoral Evidence

Changes in the distribution of employment by occupation, both within and between Canadian manufacturing and service industries, are of interest because of the important shifts in employment documented above. In addition, there is growing evidence that shifts in occupations within an industry are becoming more significant.

Table 4-2 shows the occupational distribution of employment in manufacturing and services between 1971 and 1995. It reveals that manufacturing employment is dominated by blue-collar workers while white-collar workers predominate in services. In both sectors, however, the share of white-collar workers has increased over the period 1971-95.

Table 4-2
Occupational Distribution of Employment in Manufacturing and Services,[1]
Selected Years, 1971-95

	Manufacturing				Services			
Occupational Groups	**1971**	**1981**	**1991**	**1995**	**1971**	**1981**	**1991**	1995
White-Collar	30.8	31.6	39.6	38.6	74.4	78.8	80.3	81.8
Blue-Collar	69.2	68.4	60.4	61.4	25.6	21.2	19.7	18.2
White-Collar High-Skilled	12.7	15.0	20.4	21.6	33.3	34.3	36.9	38.4
White-Collar Low-Skilled	18.0	16.5	19.2	16.9	41.1	44.4	43.4	43.4
Blue-Collar High-Skilled	17.8	17.1	16.2	15.9	6.6	5.7	4.9	4.1
Blue-Collar Low-Skilled	51.5	51.3	44.1	45.5	18.9	15.6	14.7	14.1

1 Shares exclude employment in postal services, religious services and public administration.
Source: Estimates by the authors, based on data from the Canadian Occupational Projection System

Upskilling in manufacturing and services is also evident at a finer disaggregation of occupations. The bottom portion of Table 4-2 shows changes in the distribution of employment among various categories combining blue- and white-collar occupations with high and low skill levels. It shows that in both manufacturing and services, blue-collar low-skilled workers were in decline while demand for white-collar high-skilled workers increased.

There is one interesting observation to make about the pattern of occupational shifts in manufacturing and services when it is compared to the pattern observed for the economy as a whole. As depicted in Table 4-1 above, upskilling in the economy as a whole was fairly evenly distributed over the 1971-91 period, with about half of the increase in the share of white-collar employment occurring between 1971 and 1981, and the other half occurring between 1981 and 1991. In manufacturing, on the other hand, we find that the upskilling occurred mainly during the 1980s. In the case of services, the pattern of upskilling resembles that of the economy as a whole. This suggests that the manufacturing sector underwent profound structural changes in the 1980s, which were likely accelerated by the severe recession of the early part of the decade.

Shifts Between and Within Industries

Does the upskilling observed in manufacturing and services reflect the fact that employment has shifted towards industries that employ more high-skilled workers (between-industry effect) or the fact that it is occurring in all industries (within-industry effect). To answer this question, we follow OECD (1996) and decompose the growth of employment in high-skilled occupations[22] into components attributable to employment shifts between industries and within industries.[23] While OECD (1996) only presents data for the service sector, we include calculations for the manufacturing sector. The results of this decomposition for both manufacturing and services over the period 1981-95 are shown in Table 4-3.

The estimates show that within-industry changes account for most of the change in both services and manufacturing. Between 1981 and 1995, within-industry changes accounted for

Table 4-3
Decomposition of Changes in High-Skilled Employment,[1] 1981-95

	Total Annualized Change in the Share of High-Skilled Employment	Between-Industry Component	Within-Industry Component	Percent Contribution of Within-Industry Component
Total	0.26	0.02	0.24	91.6
Manufacturing	0.55	0.07	0.48	87.0
Services	0.25	0.03	0.22	91.6

1 High-skilled employment refers to the sum of the white- and blue-collar high-skilled groups.
Source: Estimates by the authors, based on data from the Canadian Occupational Projection System

87 percent of upskilling in manufacturing and for 90 percent in services. These results suggest that upskilling is pervasive and appears to be occurring in all industries. They are consistent with our earlier finding that all sectors of the economy are moving towards more knowledge- and technology-intensive activities, and also with OECD (1996), which found that the overall change in most of the countries studied was mostly accounted for by within-industry changes.[24]

While there is evidence of upskilling in the Canadian labour market, we do not attempt to relate this phenomenon to the impact of trade or technology. However, the evidence of upskilling at the level of the firm or establishment does relate technology to changes in the skill distribution of employment. Several Canadian studies and surveys have examined the changes in the occupational composition of employment at the firm level. These studies generally try to assess the impact of the introduction of new technology on the skill distribution of jobs in a firm.

One such study is the Working With Technology Survey (WWTS), a longitudinal survey that collects data on the impact of computer-based technology (CBT) in Canadian establishments.[25] In the latest edition of the survey, the data show that shifts in the occupational profile of respondents reflect a process of upskilling (McMullen, 1996). Most jobs created as a result of the introduction of CBT were high-skilled jobs, while most of the jobs eliminated were in the low-skilled categories. In addition, the survey found that all occupational groups experienced an increase in the skill requirements of their job as a result of the introduction of CBT.[26]

In another study, Baldwin & Da Pont (1996) combine the findings of several surveys of the Canadian manufacturing sector to determine whether the introduction of new technologies requires workers with higher skills. Their results show that, depending on the technology, the skill requirements of jobs increased in most firms adopting new technologies (see also Baldwin, Gray & Johnson, 1995).

Finally, OECD (1996) reviewed the international literature on the relationship between technology and skills. The study concluded that the evidence points to a positive relationship between technology skills: new technologies tend to raise the skill level required of the workforce.

Table 4-4
Employment Changes (%), by Educational Attainment, All Working-Age Groups, 1980-95

	1980-95		1990-95	
Educational Attainment	**Average Annual Growth Rate**	**Total Change**	**Average Annual Growth Rate**	**Total Change**
Elementary	-5.8	-58.9	-6.8	-29.2
High School (Completed or Not)	-1.2	-16.2	-2.2	-10.7
Some Postsecondary	2.1	35.6	0.2	-1.0
Postsecondary Diploma	8.1	234.4	3.6	19.5
University Degree	4.6	95.2	5.2	28.4

Source: Statistics Canada, *Labour Force Survey*.

Changes in the Distribution of Employment by Education and Experience

An examination of the data on employment by educational attainment[27] and experience indicates that the employment outcomes of those with little education or labour market experience have been deteriorating since the early 1980s. Following the common practice in the literature, age is used as a proxy for experience in our analysis.

Table 4-4 compares employment growth by educational attainment over the 1980-95 and 1990-95 periods. The table shows that, between 1990 and 1995, the employment of those with the lowest level of educational attainment declined at an average annual rate of 6.8 percent, compared to a rate of 5.8 percent over the 1980-95 period. This is in contrast to the employment growth of those with a university degree, which increased at an average annual rate of 5.2 percent in 1990-95 versus a rate of 4.6 percent over the 1980-95 period. Thus the gap between poorly and highly educated workers appears to have widened since the beginning of the 1990s.

Table 4-5
Employment Changes (%), by Age Group, 1980-95

	1980-95		1990-95	
Age Group	Average Annual Growth Rate	Total Change	Average Annual Growth Rate	Total Change
15-24	-2.0	-26.4	-2.7	-13.1
25-44	2.3	41.1	0.3	1.6
45 and over	2.0	35.2	3.1	16.5

Source: Statistics Canada, *Labour Force Survey.*

Table 4-6
Employment Changes (%), by Educational Attainment, 15-24 Age Group, 1980-95

	1980-95		1990-95	
Educational Attainment	Average Annual Growth Rate	Total Change	Average Annual Growth Rate	Total Change
Elementary	-6.6	-65.9	-10.2	-41.5
High School (Completed or Not)	-4.1	-47.0	-5.0	-22.6
Some Postsecondary	1.6	27.2	0.2	1.1
Postsecondary Diploma	3.0	55.7	-0.3	-1.4
University Degree	0.8	12.3	3.7	20.2

Source: Statistics Canada, *Labour Force Survey*.

This conclusion also applies to those with little labour market experience. Table 4-5 shows that youth employment declined substantially between 1980 and 1995, while the employment of more experienced workers increased. The decline in youth employment also accelerated during the 1990s, at an average annual rate of 2.7 percent versus a rate of 2 percent over the 1980-95 period.

Although some of these employment changes are partly due to changes in the age composition of the labour force, they are also the result, in part, of the value placed on experience by the market. As shown in Table 4-6, the deterioration of labour market outcomes for young participants was mostly borne by those with the lowest levels of educational attainment. Employment for those with only an elementary education decreased at an average annual rate of over 10 percent between 1990 and 1995. This is in contrast to the employment of university-educated youth, which increased at an average annual rate of almost 4 percent.

The data on labour force participation point to similar patterns. Table 4-7 shows the participation rate, unemployment rate, and employment/population ratio by level of educational attainment for the working-age population over the period 1980-95. These figures show that the

employment/population ratio of those with only elementary education fell from 40.2 percent in 1980 to 23.7 percent in 1995. This resulted mostly from a decline in labour force participation rates for this group, which fell from 44.2 percent to 27.8 percent, but it also took the form of higher unemployment: the unemployment rate increased from 9.1 to 15 percent. In contrast, labour force participation and employment rates showed little change for those with a post-secondary certificate or those with a university degree.

The data on labour force activity by age show similar patterns of labour market outcomes for those with little labour market experience. As shown in Table 4-8, the employment/population ratio of those aged 15-24 declined from 59 percent in 1980 to 52.5 percent in 1995. In contrast, the employment population ratio of those aged 25-44 increased from 74.6 to 77 percent over the same period.

Table 4-7
Labour Force Activity (%), by Educational Attainment, All Working-Age Groups, Selected Years, 1980-95

	Participation Rate				Unemployment Rate				Employment/Population Ratio			
Educational Attainment	**1980**	**1985**	**1990**	**1995**	**1980**	**1985**	**1990**	**1995**	**1980**	**1985**	**1990**	**1995**
Elementary	44.2	40.1	35.7	27.8	9.1	13.1	12.6	15.0	40.2	35.2	31.2	23.7
High School (Completed or Not)	67.0	66.9	66.1	61.3	8.6	12.4	9.8	12.0	61.2	58.6	59.6	53.9
Some Postsecondary	72.3	73.2	73.5	70.5	6.5	9.6	8.0	10.1	67.6	66.2	67.7	63.4
Postsecondary Diploma	76.6	79.7	79.6	76.9	5.1	7.6	6.3	7.9	72.7	73.7	74.6	70.8
University Degree	84.4	85.5	85.6	83.8	3.1	5.0	3.7	4.9	81.8	81.0	82.3	79.6

Source: Statistics Canada, *Labour Force Survey.*

As depicted in Table 4-9, the situation of poorly educated youth, in particular, has shown a marked deterioration. The employment/population ratio of young people with only elementary schooling fell from 37.7 percent to 23.8 percent between 1980 and 1995. This has resulted from both a sharp decline in the labour force participation of this group – from 48.5 to 33 percent – and a sharp increase in its unemployment, from 22.2 to 27.9 percent. In contrast, young people with a postsecondary certificate or a university degree fared much better, showing patterns similar to those of the overall population.

Table 4-8
Labour Force Activity (%), by Age Group, Selected Years, 1980-95

	Participation Rate				Unemployment Rate				Employment/Population Ratio			
Age Group	**1980**	**1985**	**1990**	**1995**	**1980**	**1985**	**1990**	**1995**	**1980**	**1985**	**1990**	**1995**
15-24	67.8	68.1	69.2	62.9	13.1	16.3	12.7	15.6	59.0	57.0	60.4	52.5
25-44	79.3	82.7	86.0	84.5	6.0	9.5	7.7	8.9	74.6	75.0	79.4	77.0
45-64	64.4	64.4	66.3	67.2	4.7	7.5	6.0	7.4	61.3	59.5	62.3	62.2

Source: Statistics Canada, *Labour Force Survey*.

Table 4-9
Labour Force Activity (%), by Educational Attainment, 15-24 Age Group, Selected Years, 1980-95

	Participation Rate				Unemployment Rate				Employment/Population Ratio			
Educational Attainment	**1980**	**1985**	**1990**	**1995**	**1980**	**1985**	**1990**	**1995**	**1980**	**1985**	**1990**	**1995**
Elementary	48.5	44.9	45.5	33.0	22.2	27.4	25.0	27.9	37.7	32.6	34.1	23.8
High School (Completed or Not)	67.8	67.6	67.1	57.6	14.0	18.3	14.6	18.7	58.3	55.3	57.3	46.8
Some Postsecondary	66.5	67.5	69.4	65.0	9.3	11.8	9.3	12.4	60.3	59.4	62.9	56.9
Postsecondary Diploma	82.2	82.7	83.6	79.3	8.7	10.3	8.7	11.0	75.0	74.2	76.3	70.6
University Degree	81.4	82.8	83.2	79.6	7.0	9.6	6.6	8.6	75.7	74.9	77.8	73.4

Source: Statistics Canada, *Labour Force Survey*.

It is important to note that those with little experience or education have traditionally had higher unemployment rates and lower employment rates than those with more education and experience. The changes in the composition of employment depicted above indicate that this pattern has become more pronounced during the 1990s.

The evidence on changes in employment and labour force activity by level of educational attainment and experience indicates that the demand for workers with high skills has increased. In contrast, the demand for low-skilled workers has decreased. Note that our analysis does not address the question of whether these developments are due to demand-side or supply-side factors. However, there does appear to be a concordance between demand-driven changes in the global economy, such as those occurring in trade and technology, and the better labour market performance of high-skilled workers.

Changes in Earnings by Education and Experience

Has the apparent increase in the demand for highly skilled workers led to an increase in the wages they earn? In this section, we examine changes in the earnings of individuals with various levels of education and experience, as this information also provides an indication of how workers with different skill sets fare on the labour market. It also gives an idea of the value the market places on skills and knowledge. We begin with a brief analysis of changes in annual earnings of workers with different levels of educational attainment, which will be followed with a similar exercise for workers with different amounts of labour market experience.

Returns to Education

Following Riddell (1995), the ratios of annual earnings of workers for the five possible pairings of the different educational attainment groups were computed for the 1981-93 period. Chart 4-1 depicts the time-series behaviour of the ratio of average annual earnings of one educational group to that of a group with less education.

The earnings of each group with more than high school education have increased relative to those with only elementary schooling. The largest relative increases occurred for those with a postsecondary certificate or a university degree. Between 1981 and 1993, the earnings premium for the former group increased from about 20 percent to about 35 percent while that for the latter group rose from about 80 percent to over 105 percent.

A comparison between the relative earnings of those with nine to 13 years of schooling to those with a postsecondary or higher diploma reveals that the premium has also risen for those with more education. However, the earnings for those with only some postsecondary education actually fell relative to those with nine to 13 years of schooling.

The next two panels show that the earnings of those who have either completed a postsecondary certificate or graduated from university increased relative to those who failed to complete postsecondary education. The premium associated with the completion of a postsecondary certificate and a university degree increased from about 20 percent to over 45 percent and from 90 percent to about 115 percent, respectively. In contrast, the earnings of those with a postsecondary certificate relative to those with a university degree remained fairly stable over the 1981-93 period.[28]

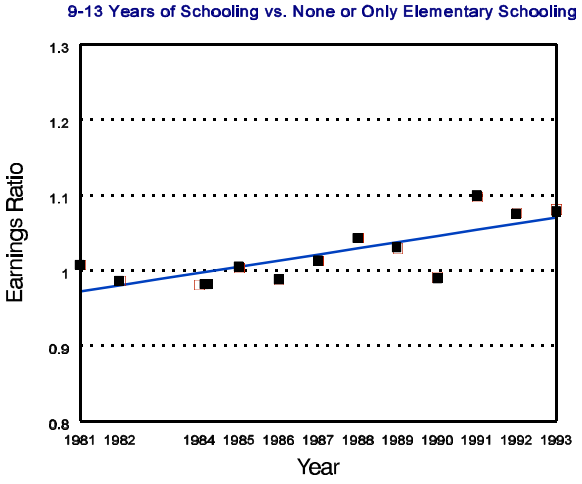
In summary, the evidence reported in Chart 4-1 suggests that the returns to education have recently increased in Canada.

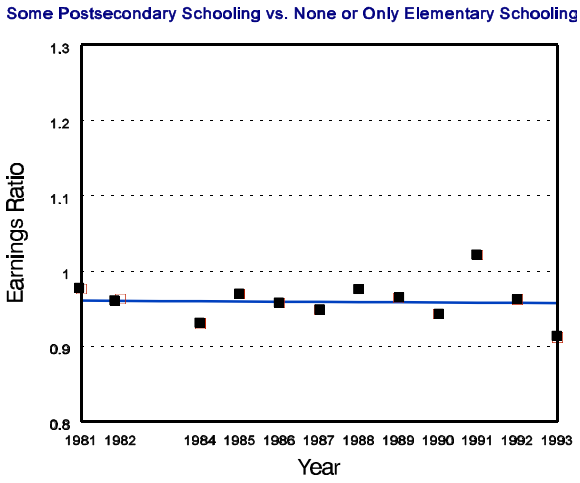
Returns to Experience

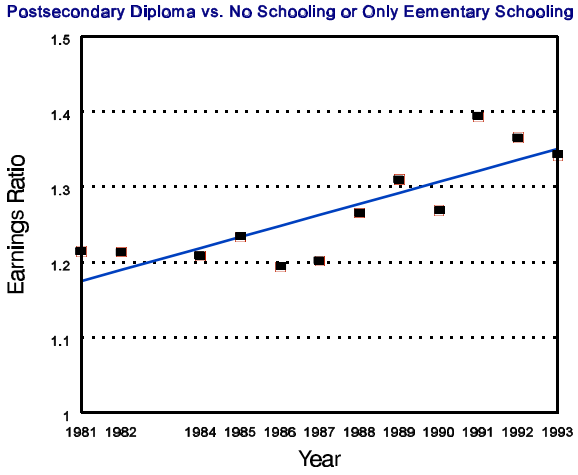
Using the same methodology as above, the ratios of average earnings of an older worker group to a younger worker group were computed over the 1981-93 period. These are depicted in Chart 4-2 along with a regression line fitted to the data.[29]

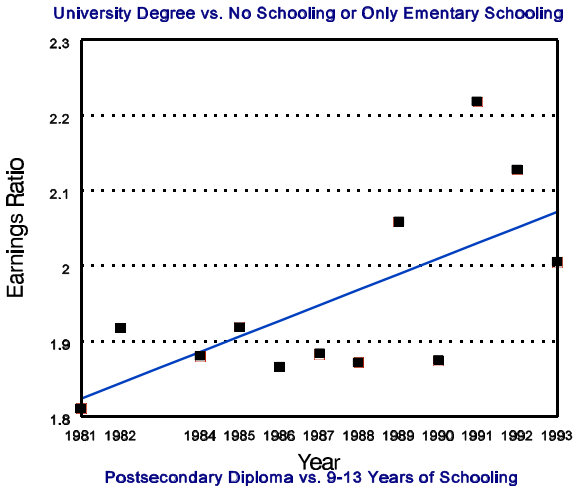
Chart 4-2 shows that the relative earnings of more experienced workers versus those of less experienced workers increased for all but two pairs (55-64 vs. 35-44 and 55-64 vs. 45-54). The most dramatic increase, however, was in the earnings of those aged 25 and over relative to those aged 15-24. Riddell (1995) argues that this substantial increase in the gap between the earnings of young and adult workers reflects both the upward trend in returns to experience and, to a larger extent, the more severe impact of the 1981-82 and 1990-92 recessions on the earnings of young workers. This latter impact is illustrated by the sharp increases in the relative earnings of those aged 25 and over during these two recessions.

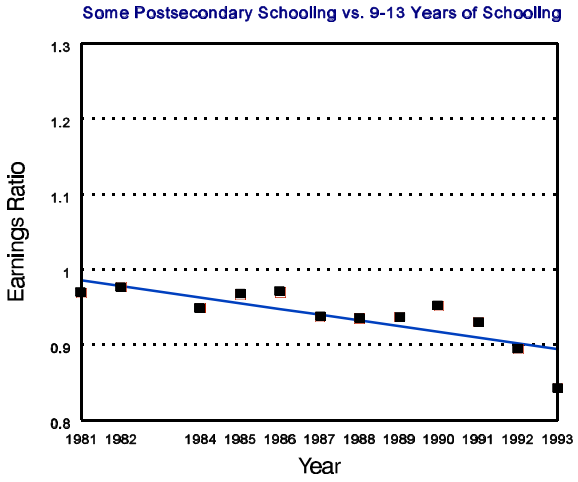
Chart 4-1
Earnings Ratios: Educational Attainment Pairings, 1981-93











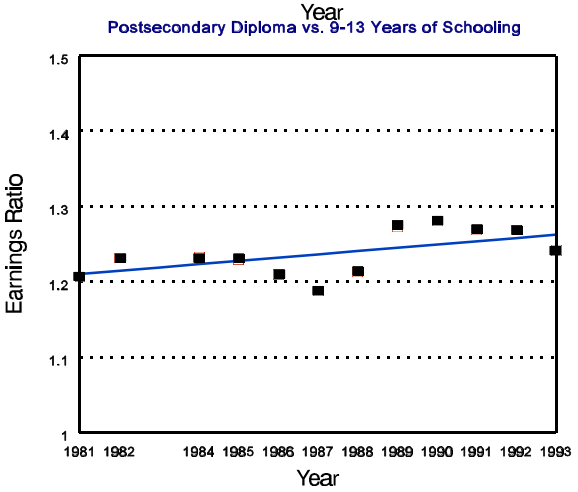
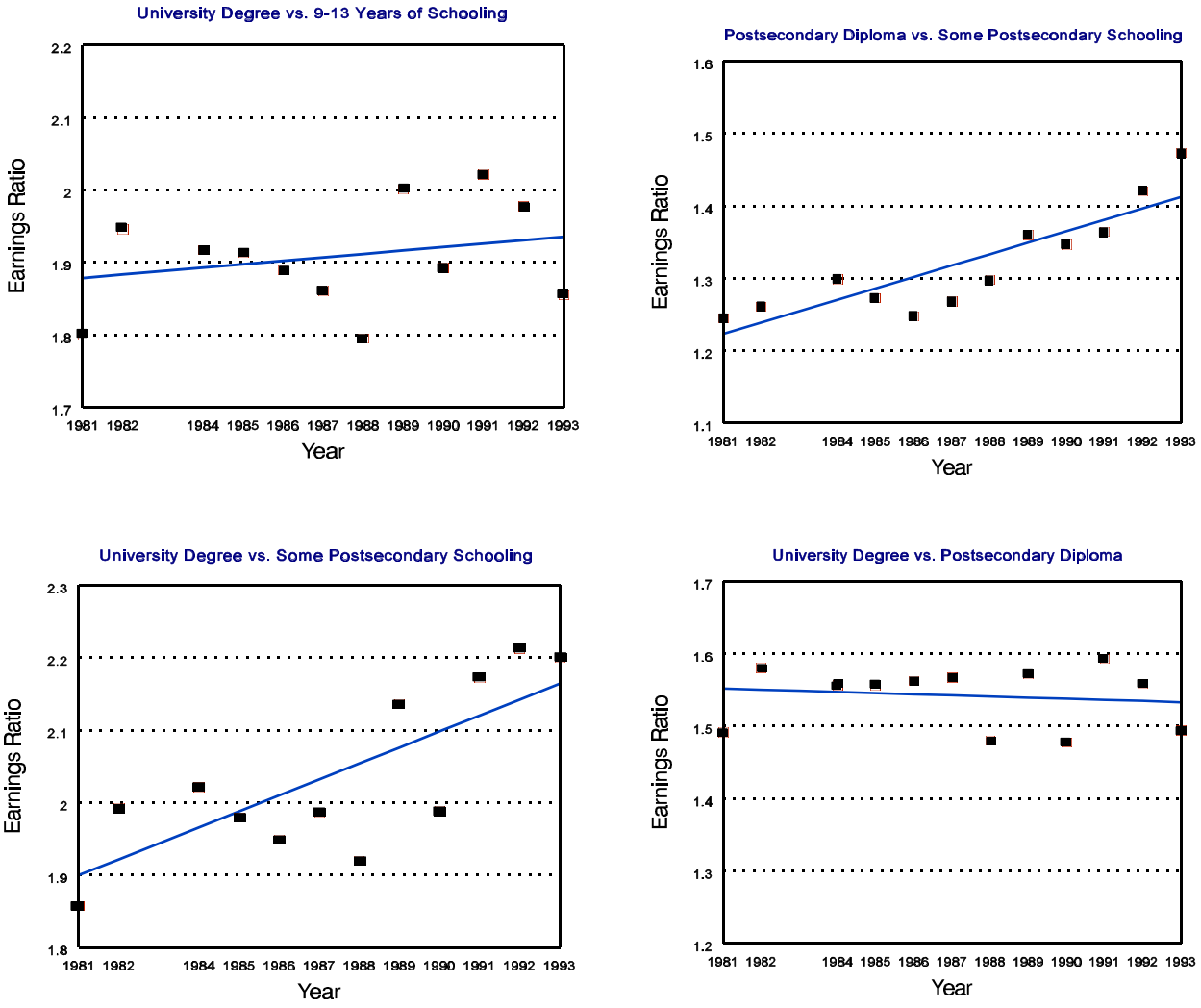


Chart 4.1
Earnings Ratios: Educational Attainment Pairings, 1981-93 (cont d)



Source: Source: Authors' calculations based on data from the *Survey of Consumer Finances*, Statistics Canada

Chart 4-2
Earnings Ratios: Age Group Pairings, 1981-93

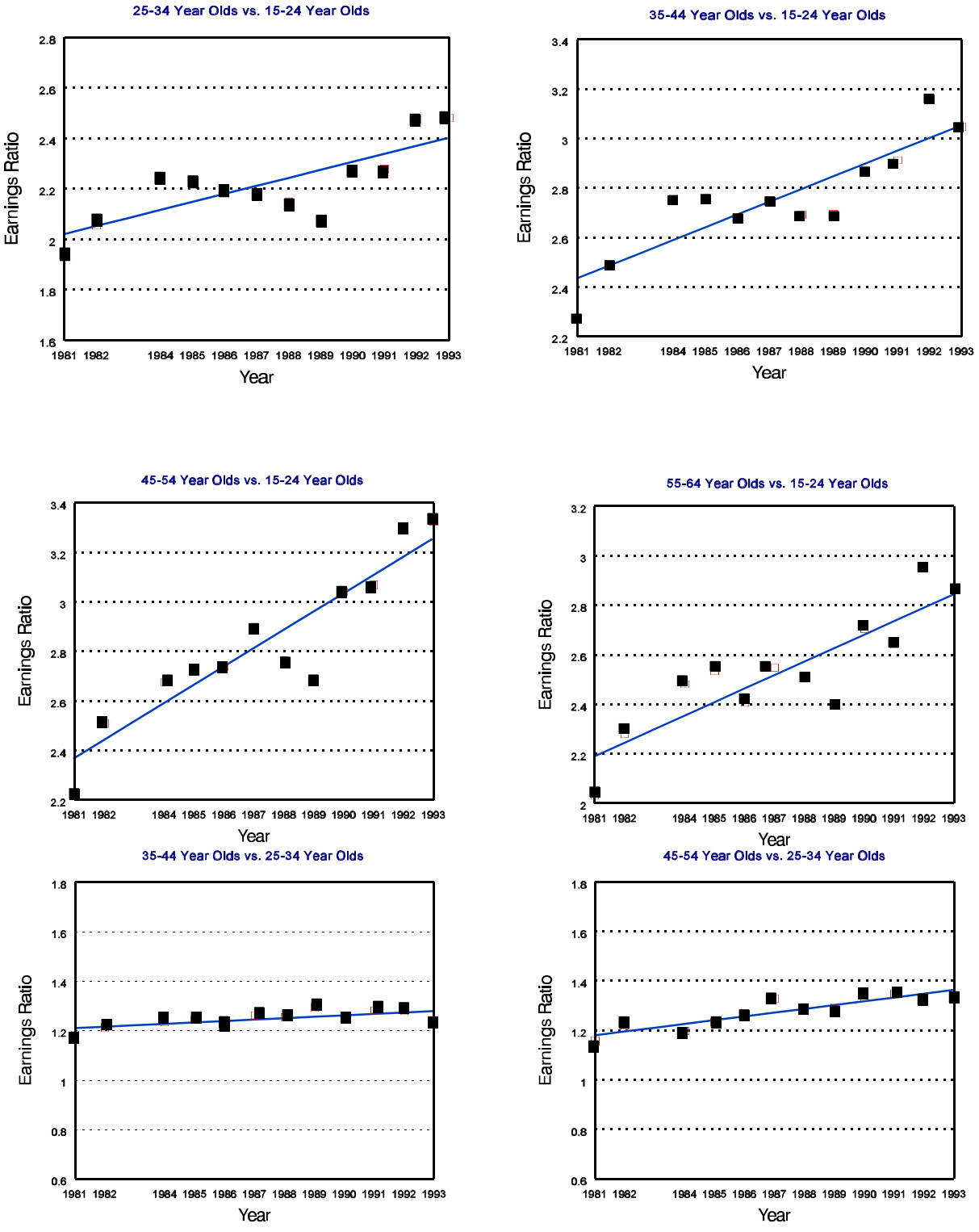
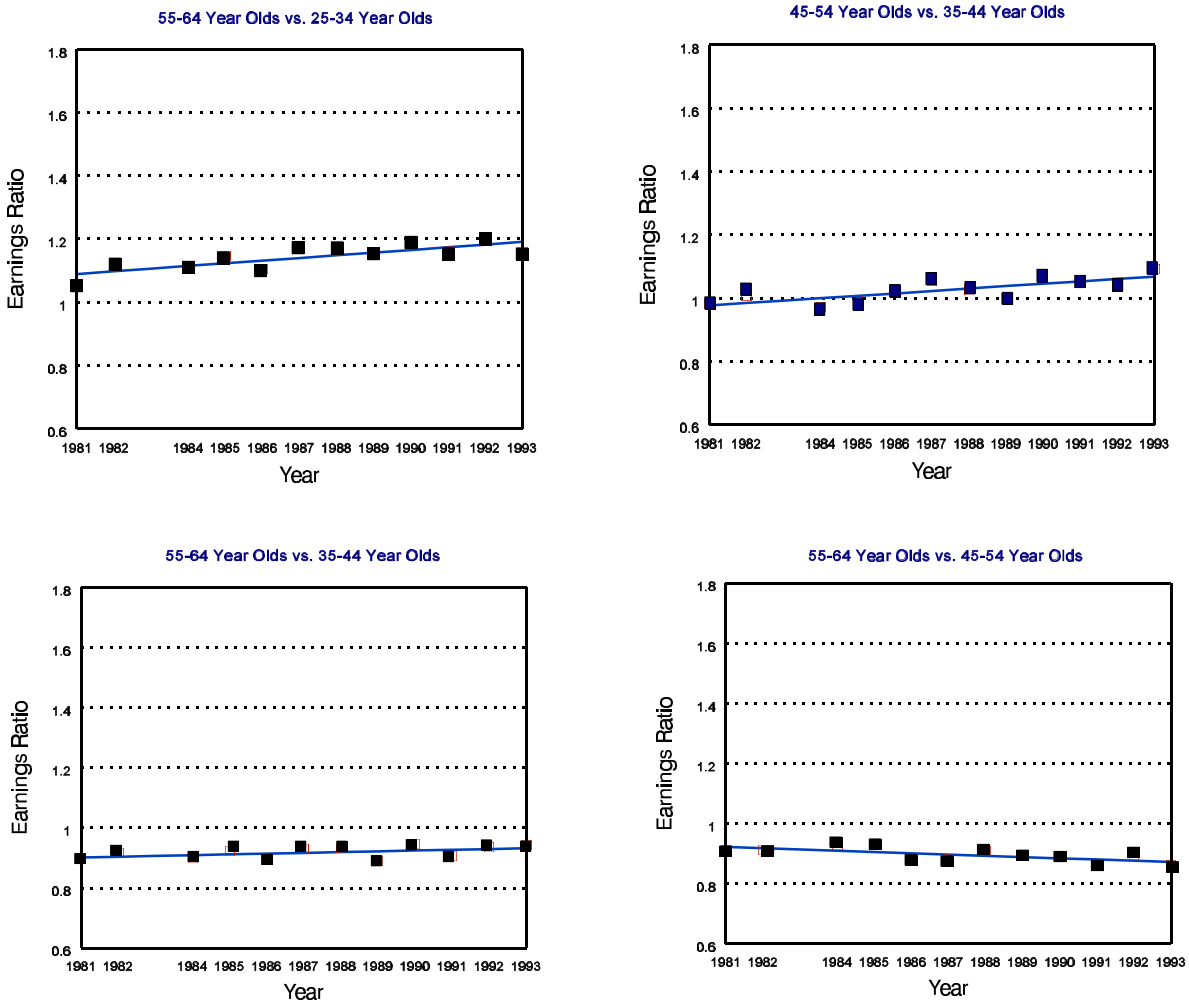


Chart 4.2
Earnings Ratios, Age Group Pairings, 1981-93 (Cont d)



Source: Authors' calculations based on data from the *Survey of Consumer Finances*, Statistics Canada

Summary

The main findings of this section are as follows:

- Shifts in the occupational structure of employment indicate an increase in the proportion of highly skilled workers in the economy.
- Upskilling is occurring within both the manufacturing and service sectors. Upskilling is mainly the result of changes in skill profiles within rather than between industries.

  - Firm-level evidence indicates that upskilling is also occurring within Canadian establishments as a result of the introduction of new technologies.

- The evidence on changes in the composition of labour force activity and in relative earnings by age and education indicates that workers with high skills enjoy better employment and earnings prospects than those with lower skills, which suggests that the demand for highly skilled workers has increased.

The evidence indicates that the structure of labour demand has shifted in favour of skilled workers. This finding appears to be consistent with the results of our analysis of sectoral employment shifts in Canada – namely, that employment growth is increasingly driven by knowledge-intensive industries and that trade and technology are increasingly important in determining the structure of labour demand.

The differences in the employment and earnings outcomes of workers with different skills are also likely, however, to be a consequence, at least in part, of the severity of the recessions of the early 1980s and early 1990s. In particular, it has been argued that sharp increases in the earnings of those aged 25 and over relative to the earnings of those aged 15-24 during the last two recessions were mainly cyclical in nature (Riddell, 1995). Nonetheless, the evidence on medium-term changes in the occupational distribution of employment suggests that structural factors such as globalization and technological change are also at play.

Whether the increase in the demand for high-skilled workers relative to low-skilled workers is due to technology or trade is still a matter of some debate. While the objective of this study is not to resolve that issue, Canadian evidence on the issue of the complementarity between technology and skills is mixed. Firm-level evidence suggests that the complementarity is strong, but sectoral evidence does not support this hypothesis (Lee, 1996; Betts, 1994). Betts (1994) shows that technological change has been biased away from blue-collar workers. On the issue of trade, our evidence suggests that overall, trade played a significant role in generating employment in Canada over the 1971-91 period, although that effect was negligible in 1986-91.[30]It should be remembered, however, that technology and trade are strongly interrelated and that both factors are at work.[31]

In the end, whether the increase in the demand for skilled workers is attributable to the effects of increased trade or technological change is largely irrelevant to those most concerned – namely, the workers. The bottom line is that skills and knowledge are becoming increasingly important in adjusting to the emergence of the knowledge-based economy that has been described in this study.

5. CONCLUSIONS

The main objective of this study was to examine structural change and employment performance in Canadian industries from the perspective of the shift towards a knowledge-based economy. Specifically, we focused on three questions: Has this structural transformation led to more and better jobs? What factors have contributed to these employment shifts? And how have labour markets adjusted the new demands of the knowledge-based economy?

Our analysis of the changes in the structure of employment in Canada reveals that knowledge and innovation are increasingly critical to job creation. In manufacturing, high-knowledge and technology-intensive industries have experienced the highest employment growth. In addition, an increasing proportion of employment is accounted for by industries that require workers with more skills and that pay higher wages. In contrast, low-knowledge, low-technology, low-wage, and low-skill industries have shed jobs. That being said, the engine of employment growth remains the service sector, with gains in employment coming from both high- and low-knowledge industries in that sector. Nevertheless, our results suggest an increasing complementarity between knowledge, innovation, and employment growth in Canadian industries.

The factors contributing to changes in employment are shifting in importance. Domestic demand and labour productivity remain important contributors to change, particularly in services, but the roles of trade and technology are growing.

Trade has emerged as a key catalyst of structural change in employment performance, particularly in the 1980s. This not surprising in a small open economy like Canada, where trade intensity (exports plus imports as a proportion of GDP) was over 60 per cent in 1991 and has risen to over 70 per cent in 1994.

Exports have become a dominant factor in employment growth, particularly in high-knowledge, high-technology, and high-wage manufacturing industries. Conversely, import penetration has adversely affected employment growth in low-knowledge, low-wage, low-technology, low-skilled, and labour-intensive manufacturing industries. While trade has always been a important factor affecting employment growth in the resource sector, its importance for employment growth in the service sector is also increasing, particularly in high- and medium-knowledge services such as business services and finance, insurance, and real estate.

In contrast to the OECD finding that the net employment effects of changes in trade in OECD countries have been small, we find that trade had a significant net impact on changes in employment in Canada over the period 1971-91. Our estimates show that 719,000 jobs were created as a result of trade, which accounted for about 23 percent of new employment generated. However, the net impact of trade was slightly negative during the latter half of the 1980s and

early 1990s. Structural change due to trade led to job losses in less innovative manufacturing industries while employment grew in the more innovative sectors of the economy.

In a recent report, OECD (1996) argues that technology and productivity growth are central to the current employment debate in industrialized countries. Despite the fact that we use a crude measure of technology, we find that the importance of technology in employment growth in Canadian industries has increased, particularly in some services industries. On balance, the evidence shows a positive relationship between productivity and employment in technology-intensive industries that are characterized by innovative behaviour and the extensive use of advanced technologies.

That being said, we suspect that our findings regarding the net effect of trade on employment may be biased upward because our methodology does not take into account the interdependence of trade and technology and that between import penetration and productivity growth.

While knowledge and innovation are increasingly critical to job creation, the transition to a knowledge-based economy has been slow in Canada. The evidence shows that the pace of structural change has not accelerated over the past 20 years and that knowledge-intensive industries still account for only a small proportion of total employment in Canada – about 15 percent in 1991. Recent evidence shows that those OECD economies with a faster pace of structural change also enjoyed higher rates of employment growth (OECD, 1994). In Canada, the slow pace of change may have contributed to the emergence of an innovation gap relative to the other G-7 economies. The proportion of value-added accounted for by Canadian high-technology manufacturing industries increased between 1971 and 1991, but at a much slower pace than that in Canada's major OECD competitors.

If, as we contend in this study, employment is increasingly related to knowledge activities, it appears that closing the innovation gap will be critical to growth in productivity and employment, and hence to future growth in Canadian living standards. This points to the need for policies that focus on the development of the innovative capacity of the economy, in particular through higher investment in the production, distribution, and use of knowledge.

However, it is clear that even if the innovation gap were completely eliminated in manufacturing, service industries would remain the principal engine of employment growth in Canada. Our evidence shows that some service industries have proven to be very innovative and successful in competing in international markets. For example, the business services industry created a lot of jobs in the last decade, many of which resulted from the growing use of new technologies and increased trade. Therefore, there also appears to be a role for policy to promote the development of the innovative capacity of the service sector as well as the knowledge- and technology-intensive manufacturing sector.

At the same time, more traditional, labour-intensive service industries, such as the food and accommodation, and personal services industries, have proven to be important sources of jobs. While the creation of many of the jobs in service industries is closely linked to the performance of the more knowledge-intensive sectors of the economy, growth in domestic demand remains the dominant source of employment growth in these industries. This suggests that macroeconomic policies and micro structural policies in the product and labour markets will continue to be important determinants of employment growth.

In a parallel development, our findings indicate that the demand-driven forces underlying the move toward the knowledge-based economy – i.e., trade and technology – have resulted in increased adjustment in the labour market. The structure of labour demand has shifted in favour of skilled workers. Changes in the occupational distribution of employment show that upskilling is widespread in all sectors of the economy and is mainly the result of changes in skill profiles within industries rather than between industries. In addition, the increased demand for high-skilled workers has been reflected in higher relative returns to education and experience.

Thus for workers the move towards a knowledge-based economy is essentially an adjustment issue as they try to keep up with the changing requirements of the labour market. Technological change has been an important factor driving changes in labour market requirements. It has led to the creation of new types of jobs requiring new types of skills; it eliminates certain jobs and renders obsolete certain skills; and it changes the skill content of existing jobs. The resulting shift in the demand from low-skilled to high-skilled workers has led to growing adjustment difficulties for those who lack sufficient education and specialized skills. In addition, part of the effects of this shift may have translated into growing income inequality.

Young people have also borne a disproportionate share of the adjustment difficulties caused by the shift towards the knowledge economy. In their case, however, the lack of education may not have been as severe a problem as has the development of labour market skills through work experience.

The adjustment difficulties associated with the advent of the knowledge economy point to the need for policies that promote investment in education and training to improve the skills and competencies of the labour force. Successful adjustment to the knowledge economy will therefore depend on both the quality of the education system and on the institutional framework that gives workers the opportunity to obtain the reschooling and retraining they need to make the employment transitions throughout their working lives. Workers in a knowledge-based economy need to be highly skilled, flexible, and adaptable. These characteristics are critical to a successful adjustment and hence to reducing income inequality and unemployment in the long term.

The policy directions outlined above basically reflect the growing complementarity between trade, technology, and skills as evidenced by the results of our analysis of employment

performance of Canadian industries. While new technologies and increased trade clearly bring with them the opportunity for improvements in productivity, employment, and incomes, a skilled and adaptable workforce is essential for achieving these potential gains. In essence, the challenge for policy in promoting employment in the knowledge-based economy is to enhance the knowledge-creating capacity of the Canadian economy by promoting investments in both innovation and human capital.

APPENDIX A

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

	R&D Intensity	Rank	R&D Personnel per Worker	Rank	Professional R&D Personnel per Worker	Rank
Scientific & Professional Equipment	27.88	1	3.14	9	1.65	9
Communication & Other Electronics	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 & Medicine	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 & Electronics	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[2]	0.05	39	0.03	41	0.02	40
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

	R&D Intensity	Rank	R&D Personnel per Worker	Rank	Professional R&D Personnel per Worker	Rank
Other Manufacturing Industries[3]	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

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

	R&D Intensity	Rank	R&D Personnel per Worker	Rank	Professional R&D Personnel per Worker	Rank
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.
2. Other services include other business services and personal services.
3. Other manufacturing industries include clothing and leather, and other manufacturing products.
4. 1986 gross output and employment are used for the scientific and professional equipment and other manufacturing industries.
5. Gross output for computer and related services, engineering and scientific services, and management and consulting services is approximated 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	Rank	Proportion of Knowledge Workers	Rank	Proportion of Scientists & Engineers per Worker	Rank
Scientific & Professional Equipment	45.3	16	30.7	13	12.6	10
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 & Medicine	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 & Electronics	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
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

Table A-2
Human Capital, by Industry, 1986 (Cont d)

	Proportion of Workers with Postsecondary Education	Rank	Proportion of Knowledge Workers	Rank	Proportion of Scientists & Engineers per Worker	Rank
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	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

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

	Technology Intensity	Wage Intensity	Skill Intensity	Sector Orientation
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 Industries	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
Communications 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)

The classification is based on OECD (1994).

APPENDIX C

Employment Decomposition Methodology

Basic Input/Output Structure and Model

The framework examines the changes in the sectoral composition of employment in industries using Statistics Canada's input/output (I/O) model. As we know, the I/O model is a detailed accounting framework of the Canadian economy. It 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 I/O tables. At the most detailed level, they consist of 216 industries by 627 commodities (including primary inputs and various margins)[32]. Each row in the I/O 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 I/O 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 the 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 leakage factors 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 are referred to as the *indirect effects*. The direct and indirect effects are combined to form the *total effects* (Poole, 1993).

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

1. change due to domestic final demand (DFD): change in personal consumption + change in investment + change in government expenditures;
2. change due to exports (Exp);

3. change due to imports (Imp): change due to imports of final goods + change due to imports of intermediate inputs;
4. change in production techniques: change in input/output coefficients;
5. change in labour productivity: change in labour/output ratio;
6. change due to other factors: change due to market shares + change due to other leakages in substitution of final demand and intermediate goods.

The methodology takes no account of dynamic relationship among variables. For example, labour productivity growth in our accounting framework is solely labour-saving as it does not take into account any of the price and income effects. Innovations, whether they lower costs or create new products, result in higher wages and profits or in price reductions. All of these tend to increase real incomes, the demand for goods and services, and consequently employment.

The I/O model does not account directly for changes in relatives prices, in interest rates, in money supply, or in many more variables present in many typical macroeconomic models. The six sources of change listed above can probably be better described as concurrent changes observed with the changes in employment by the business sector that are themselves the result of a whole range of socio-economic changes. While there is a link between the six terms and the corresponding changes in employment, the model does not attempt a full causal measurement effect.

Change in employment can be measured in three different ways:

1. The first measure provides the **absolute changes** of employment by sector between a comparative year (T) and a base year (t):

   $$g_T - g_t$$

   where g is a vector of total employment by sector. From these differences, it is easy to identify the growing and shrinking industries over the time 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 employment growth rates** – referred as growth rate indicator, is a commonly used indicator of change. This is a more meaningful indicator as 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 as **relative share indicator**. It measures change relative to the average rate of growth for the economy:

$$100\ x\ [(g_T - \beta g_t) / Eg_T] \quad \text{where } \beta = Eg_T / Eg_t$$

where variable β is the trend of employment growth between the two periods. When the relative share indicator for a given sector is positive, this implies that employment in the sector grew at a faster rate than the overall economy while the opposite is true in the case of negative values. Magnitudes take into account the relative importance of the sector within the economy.

We also report two other indicators of change – growth rate and relative share indicators – which provide a useful description of the structural change in the economy between two periods. Because the focus is on long-term changes in employment as opposed to cyclical movements, the analysis is conducted over a relatively long period (1971-91).

Unfortunately, the I/-O tables are *not* available on a consistent constant-dollar basis over the entire period 1971 to 1991. Our analysis has to be split into three sub-periods – 1971-81, 1981-86, and 1986-91 because the I/O tables in constant dollars exist on a consistent basis from 1971 to 1981, from 1981 to 1986, and from 1986 to the most recent period (1991). This means that 1986 tables are evaluated in 1981 dollars but not in 1971 dollars. Similarly, the most recent 1991 tables are evaluated in 1986 dollars, but not in 1981 or 1971 dollars. The calculations for all the measures of change were done for the three above-mentioned periods.[33]

APPENDIX D

Mathematical Derivation of the Employment Growth Decomposition Model

This appendix presents the mathematical expressions and their derivations used to calculate the various growth decomposition indicators reported in the paper. While based on OECD *Structural Change and Industrial Performance (1992),* the present 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[34]

This section presents the basic definitions, the equilibrium condition, and other relations of the structural model. The model is based on the constant-price Canadian input/output tables. Because of the structure of the model, it is convenient to present the labour determination model as an extension of the output determination model.

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

$$d_t = d_p + e_c + \overline{e} + x^*_D + x^*_R \qquad (1)$$

where d_p is the vector of intermediate demand (for the production process), e_c is the personal consumption vector, $\overline{e}$ 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:

$$d_p = Bg \qquad (2)$$

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 o_t may come from the business sector's current production q, from imports for domestic purposes m_D, from imports for re-export purposes m_R, from supply from the government sector a, from the withdrawals from inventories <, or from other leakages from the business sector s_c or s_o[35]:

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

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-export purposes:

$$m_R = x^*_R \tag{4}$$

We may notice that re-exports have no effect on employment 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:

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

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

$$< = \hat{\beta}_c\, e_c + \hat{\beta}_{\bar{e}}\bar{e} + \beta_x x^*_D + \hat{\beta}_I Bg \tag{7}$$

$$s_c = <^{*} e_c \tag{8}$$

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

The domestic market-share matrix – the last set of model parameters – 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 is equal to 1, except for non-competing imports (tropical fruits, for example) in which case all shares are zero.

We need one last relationship to solve the model for gross output – namely, the equilibrium condition:

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

As an extension of the above model, we can evaluate labour requirements l as a linear application of gross output:

$$l = \hat{\eta} g \tag{12}$$

where η is a parameter of labour/output ratios that can be expressed in terms of number of jobs per million dollars of output, number of worked hours per thousand dollars of output, or some similar ratio that can be estimated.

The Reduced-Form Employment Determination Model

For the model described above, we can obtain the reduced form of any of the endogenous variables: d_t, d_p, o_t, q, m_D, a, $<$, s_c, s_o, l or g. Our goal is to set the basis for the growth decomposition model for employment. For convenience, we proceed in two steps: first, we express the reduced form for gross industry output by substituting (1) to (10) into (11) and solve for g:

$$g = \left[I - D\,(I - \hat{\mu}_I - \hat{\alpha}_I - \hat{\beta}_I - \hat{\gamma}_I)B\right]^{-1} D\Big[(I - \hat{<} - \hat{\mu}_c - \hat{\alpha}_c - \hat{\beta}_c - \hat{\gamma}_c)e_c + (I - \hat{\mu}_{\bar{e}} - \hat{\alpha}_{\bar{e}} - \hat{\beta}_{\bar{e}} - \hat{\gamma}_{\bar{e}})\bar{e} + (I - \hat{\alpha}_x - \hat{\beta}_x - \hat{\gamma}_x)x^*_D\Big] \tag{13}$$

Second, labour requirements follow directly from (12).

The final right-hand-side expression for l contains nothing but exogenous demand e_c, $\bar{e}$, and x^*_D as well as all model parameters.

The Growth Decomposition Model

The employment determination model can be evaluated using data for different periods, and one can thus say from an accounting perspective that the difference in employment between two periods can be "explained" by the changes in exogenous demand e_c, $\bar{e}$, and x_D, and model parameters. The growth model is used to analyze the observed change in employment per industry l_1 from a reference year to its value l_0 in a comparative year. We can analyze the growth in many different ways. Let us first look at the absolute difference model for employment:

$$\Delta l = \hat{\eta}_1 g_1 + \hat{\eta}_0 g_0 \tag{14}$$

In the discrete mode, there is no single way to write the decomposition. The following derivation shows how to arrive at the decomposition with base-year coefficients and comparative-year weights. 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. The two possible decompositions are:

$$\Delta l = \hat{\eta}_1 g_1 - \hat{\eta}_0 g_0 + \hat{\eta}_0 g_1 - \hat{\eta}_0 g_1 = \hat{\eta}_0 \Delta g + \Delta\hat{\eta} g_1 \tag{15}$$

and

$$\Delta l = \hat{\eta}_1 g_1 - \hat{\eta}_0 g_0 + \hat{\eta}_1 g_0 - \hat{\eta}_1 g_0 = \hat{\eta}_1 \Delta g + \Delta \hat{\eta} g_0 \tag{16}$$

where

$$\Delta g = g_1 - g_0 = A_1^{-1} D_1 \left[(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1}) e_{c1} + (I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1}) \bar{e}_1 + (I - \hat{\kappa}_{x1}) x^*_{D1} \right]$$

$$- A_0^{-1} D_0 \left[(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0}) e_{c0} + (I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0}) \bar{e}_0 + (I - \hat{\kappa}_{x0}) x^*_{D0} \right] \tag{17}$$

and

$$A = I - D\,(I - \hat{\mu}_I - \hat{\alpha}_I + \hat{\beta}_I + \hat{\gamma}_I) B$$
$$\hat{\kappa}_c = \hat{\kappa} + \hat{\alpha}_c + \hat{\beta}_c + \hat{\gamma}_c$$
$$\hat{\kappa}_{\bar{e}} = \hat{\alpha}_{\bar{e}} + \hat{\beta}_{\bar{e}} + \hat{\gamma}_{\bar{e}}$$
$$\hat{\kappa}_x = \hat{\alpha}_x + \hat{\beta}_x + \hat{\gamma}_x$$

For the analysis, we group the terms on the right-hand side so as to isolate various sources of change in employment. Again, there is no single way to write the decomposition for Δg. The following derivation shows how to arrive at the decomposition with base-year coefficients and comparative-year weights. Let

$$H = (I - \hat{\mu}_c - \hat{\kappa}_c) e_c + (I - \hat{\mu}_{\bar{e}} - \hat{\kappa}_{\bar{e}}) \bar{e} + (I - \hat{\kappa}_x) x^*_D \tag{18}$$

We can therefore write (17) as:

$$\Delta g = A_1^{-1} D_1 H_1 - A_0^{-1} D_0 H_0 \tag{19}$$

The decompositions for Δg are:

$$\Delta g = A_1^{-1} D_1 H_1 - A_0^{-1} D_0 H_0 + A_0^{-1} D_1 H_1 - A_0^{-1} D_1 H_1 \tag{20}$$

and

$$\Delta g = A_1^{-1} D_1 H_1 - A_0^{-1} D_0 H_0 + A_1^{-1} D_0 H_0 - A I_1^{-1} D_0 H_0 \tag{21}$$

The expressions for Δg lead to two decompositions.

First, we can write (20) in the following way:

$$\begin{aligned}\Delta g &= A_1^{-1}D_1 H_1 - A_0^{-1}[D_1H_1 - (D_1H_1 - D_0H_0)] \\ &= A_1^{-1}D_1 H_1 - A_0^{-1}[D_1H_1 - \Delta(DH)] \\ &= A_0^{-1}\Delta(DH) + (A_1^{-1} - A_0^{-1})D_1H_1\end{aligned} \tag{22}$$

We develop new expressions for $\Delta(DH)$ and for $(A_1^{-1} - A_0^{-1})D_1H_1$ that we will substitute back into (22).

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

$$\begin{aligned}\Delta(DH) = {} & D_1(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} + D_1(I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 + D_1(I - \hat{\kappa}_{x1})x^*_{D1} \\ & - D_0(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})e_{c0} + D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\bar{e}_0 + D_0(I - \hat{\kappa}_{x0})x^*_{D0}\end{aligned} \tag{23}$$

and expand it as:

$$\begin{aligned}\Delta(DH) = {} & D_1(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} + D_1(I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 + D_1(I - \hat{\kappa}_{x1})x^*_{D1} \\ & - D_0(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})e_{c0} - D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\bar{e}_0 - D_0(I - \hat{\kappa}_{x0})x^*_{D0} \\ & + D_0(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} - D_0(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} + D_0(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})e_{c1} \\ & - D_0(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})e_{c1} + D_0(I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 - D_0(I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 \\ & + D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\bar{e}_1 - D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\bar{e}_1 + D_0(I - \hat{\kappa}_{x1})x^*_{D1} - D_0(I - \hat{\kappa}_{x1})x^*_{D1} \\ & + D_0(I - \hat{\kappa}_{x0})x^*_{D1} - D_0(I - \hat{\kappa}_{x0})x^*_{D1}\end{aligned} \tag{24}$$

We can group the terms in the following way:

$$\begin{aligned}\Delta(DH) = {} & D_0(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})\Delta e_c + D_0\Delta(I - \hat{\mu}_c - \hat{\kappa}_c)e_{c1} + \Delta D(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} \\ & + D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\Delta\bar{e} + D_0\Delta(I - \hat{\mu}_{\bar{e}} - \hat{\kappa}_{\bar{e}})\bar{e}_1 + \Delta D(I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 \\ & + D_0(I - \hat{\kappa}_{x0})\Delta x^*_D + D_0\Delta(I - \hat{\kappa}_x)x^*_{D1} + \Delta D(I - \hat{\kappa}_{x1})x^*_{D1}\end{aligned} \tag{25}$$

We can write $(A_1^{-1} - A_0^{-1})D_1H_1$ the following way:

$$\begin{aligned}(A_1^{-1} - A_0^{-1})D_1H_1 &= -(A_1^{-1} - A_0^{-1})D_1H_1 \\ &= A_0^{-1}(\mathrm{A}_0 - \mathrm{A}_1)A_1^{-1} D_1H_1 \\ &= A_0^{-1}(\mathrm{A}_0 - \mathrm{A}_1)g_1\end{aligned} \tag{26}$$

We can write $\mathrm{A}_0 - \mathrm{A}_1$ the following way:

$$A_0 - A_1 = I - D_0(I - \hat{\mu}_{I0} - \hat{\kappa}_{I0})B_0 - [I - D_1(I - \hat{\mu}_{I1} - \hat{\kappa}_{I1})B_1] \quad (27)$$

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

We can expand (27) the following way:

$$\begin{aligned} A_0 - A_1 = {} & D_1(I - \hat{\mu}_{I1} - \hat{\kappa}_{I1})B_1 - D_0(I - \hat{\mu}_{I0} - \hat{\kappa}_{I0})B_0 + D_0(I - \hat{\mu}_{I0} - \hat{\kappa}_{I0})B_1 \\ & - D_0(I - \hat{\mu}_{I0} - \hat{\kappa}_{I0})B_1 + D_0(I - \hat{\mu}_{I1} - \hat{\kappa}_{I1})B_1 - D_0(I - \hat{\mu}_{I1} - \hat{\kappa}_{I1})B_1 \\ = {} & D_0(I - \hat{\mu}_{I0} - \hat{\kappa}_{I0})\Delta B + D_0\Delta(I - \hat{\mu}_I - \hat{\kappa}_I)B_1 + \Delta D(I - \hat{\mu}_{I1} - \hat{\kappa}_{I1})B_1 \end{aligned} \quad (28)$$

We can now substitute (28) into (26) and the result into (22) and substitute (25) into (22) as well, and obtain:

$$\begin{aligned} \Delta g = {} & A_0^{-1}D_0(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})\Delta e_c + A_0^{-1}D_0\Delta(I - \hat{\mu}_c - \hat{\kappa}_c)e_{c1} + A_0^{-1}\Delta D(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} \\ & + A_0^{-1}D_0(I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\Delta\bar{e} + A_0^{-1}D_0\Delta(I - \hat{\mu}_{\bar{e}} - \hat{\kappa}_{\bar{e}})\bar{e}_1 + A_0^{-1}\Delta D(I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 \\ & + A_0^{-1}D_0(I - \hat{\kappa}_{x0})\Delta x^*_D + A_0\text{-}1\ D_0\Delta(I - \hat{\kappa}_x)x^*_{D1} + A_0^{-1} + \Delta D(I - \hat{\kappa}_{x1})x^*_{D1} \\ & + A_0^{-1}D_0(I - \hat{\mu}_{I0} - \hat{\kappa}_{I0})\Delta Bg_1 + A_0^{-1}D_0\Delta(I - \hat{\mu}_I - \hat{\kappa}_I)B_1g_1 \\ & + A_0^{-1}\ \Delta D(I - \hat{\mu}_{I1} - \hat{\kappa}_{I1})B_1g_1 \end{aligned} \quad (29)$$

Finally, we can substitute the above expression in (15). We can further isolate the changes in employment resulting from changes in import substitution μ and changes in other leakages *6*. In Table D-1 we have kept as separate the terms for the changes in the import substitution of intermediate goods and the changes 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:

$$\bar{e} = e_I + e_G \quad (30)$$

The above decompositions lead to alternative indicators directly derived from them. If we divide every term by the absolute change in employment Δl, we obtain share indicators of employment growth from the various sources. If we multiply these share indicators by the average annual employment growth rate for every industry, we obtain growth rate indicators. Every term indicates how much it contributed to the growth of each industry.

The Deviation Model

An alternative model leads to measures to evaluate the relative importance of industries to the overall employment growth of the economy. The aim of the deviation model is to measure the deviations from employment 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 employment growth whereby all sectors of the economy grow at the same rate.

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

$$\lambda = \frac{\hat{i}l_1}{\hat{i}l_0} \quad \text{where } i \text{ is a summation vector.} \tag{31}$$

We can then measure the deviation of employment as follows:

$$\delta g = l_1 - \lambda l_0 \tag{32}$$

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

$$\lambda l_0 = \hat{\eta}_0 A_1^{-1} D[(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})\lambda e_{c0} + (I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\lambda \bar{e}_0 + (I - \hat{\kappa}_{x0})\lambda\, x^*_{D0}] \tag{33}$$

We can thus write the expression for the deviation of employment:

$$\begin{aligned} \delta l = {} & \hat{\eta}_0 A_1^{-1} D[(I - \hat{\mu}_{c1} - \hat{\kappa}_{c1})e_{c1} + (I - \hat{\mu}_{\bar{e}1} - \hat{\kappa}_{\bar{e}1})\bar{e}_1 + (I - \hat{\kappa}_{x1})x^*_{D1}\,] \\ & + \hat{\eta}_0 A_1^{-1} D[(I - \hat{\mu}_{c0} - \hat{\kappa}_{c0})\lambda e_{c0} + (I - \hat{\mu}_{\bar{e}0} - \hat{\kappa}_{\bar{e}0})\lambda \bar{e}_0 + (I - \hat{\kappa}_{x0})\lambda\, x^*_{D0}] \end{aligned} \tag{34}$$

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 deviations from the reference scenario *per se* but rather relative share indicators that take into account the importance of growth of each industry within the economy:

$$\Delta h = \; l_1 / \hat{i}l_1 - \; l_0 / \hat{i}l_0$$

$$= \; \{l_1 / \hat{i}l_1 - \lambda l_0 / \hat{i}l_0\} + \{\lambda l_0 / \hat{i}l_1 - l_0 / \hat{i}l_0\} \tag{35}$$

$$= \; {}^*l / \hat{i}l_1$$

We can thus divide the deviations obtained from (34) to decompose the relative share indicators by dividing every term by the scalar $\hat{il}_1$.

Table D-1

Decompositions of the Absolute Difference of Employment by Industry ΔI

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

Table D-2
Decomposition of the Deviations of Employment Relative to Balanced Growth Employment

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

ENDNOTES

1 Some studies attribute the rise of employment in services to a restructuring of manufacturing, with service activities such as janitorial work or in-house advertising being spun off from the firm. This suggests that the growth of the service sector is due to "unbundling" in the manufacturing sector – in other words, to a shift, rather than an increase, in the demand for services. Papaconstantinou (1995) notes that the evidence on this issue is not clear-cut. Studies conducted for the U.S. economy and in the United Kingdom have not found strong support for this hypothesis (Tschetter, 1987; Barker, 1990). Although both studies found that some unbundling had occurred, the effect is relatively very small in the overall growth of the service sector,and especially in fast-growing sectors such as producer services.

2 The Lilien index is calculated as:

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

while the dissimilarity index is calculated as:

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

3 OECD (1996) points out that structural change is a multidimensional concept, encompassing changes in the workings of markets at the microeconomic level, shifts in the economy's industrial composition, as well as shifts *within* industries. There is increasing evidence in a number of OECD economies that these *intra*sectoral shifts are more important than *inter*sectoral compositional shifts, with a substantial increase in the number of jobs being shifted from declining firms to growing firms. Baldwin & Rafiquzzaman (1994) provide such evidence for the Canadian manufacturing sector.

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

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

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

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

8 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 with professional R&D personnel (0.95).

9 Lee & Has (1996) note that 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 that of knowledge workers is low (0.61). To the authors, this suggests that this occupational category tends to focus on the scientific or technological capacity of an industry, and therefore may not be particularly adequate for measuring the knowledge content of service industries that are not involved in producing new processes or new products. For further details, see Lee & Has (1996).

10 These results are, in general, consistent with the findings of earlier Canadian studies (Rose, 1992; Lee & Has, 1996).

11 High-technology industries are generally associated with a number of characteristics: a strong R&D effort; the presence of high risks and large capital investment; vary rapid product and process obsolescence; strategic importance for governments; a high degree of international cooperation in R&D, production, and worldwide marketing; and the presence of highly paid or highly skilled occupations. The high-technology industries that have the highest R&D intensity in the OECD area as a whole are pharmaceuticals and medicine; computers and office equipment; electrical equipment and appliances; communications equipment and components; aircraft and parts; and scientific instruments. This list includes only those manufacturing industries which undertake R&D as part of their production process,and thus excludes services and other parts of manufacturing that are major users rather than producers of new technology (OECD, 1994).

12 Canada's high-technology exports accounted for about 14 per cent of total manufacturing exports in 1992. Much higher proportions were recorded in the United States (38 percent), Japan (36 percent), the United Kingdom (31 percent), France (23.4 percent), and Italy (15 percent) (OECD, 1994).

13 This classification is summarized in Appendix B.

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. The science-based group generally includes high-tech industries where R&D expenditures are 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).

15 This is partly due to statistical problems associated with its measurement, but also to a common perception that manufacturing is more important. In fact, the service sector is made up of a heterogeneous mix of activities that defies generalization, and the very distinction between manufacturing and services is not clear cut. For example, radio and television broadcasts are viewed as services while newspapers are considered as manufacturing products. Estimates show that for manufacturing as a whole, at least three quarters of the value-added associated with a manufacturing product is due to service activities carried out by the manufacturer (OECD,1988, 1994; Papaconstantinou, 1995).

16 The regression results for the manufacturing industries for the period 1971-91 show that employment growth relative to total manufactuting equals .096 + .14*productivity relative to total manufacturing (R^2=.13 and t-statistic for the productivity coefficient is 1.75).

17 Empirical studies conducted in the United States generally conclude that trade is not the primary cause of the economic problems experienced by the less-skilled workers in advanced countries (Katz & Murphy, 1992; Borjas & Ramey, 1993; Murphy & Welch, 1992; Lawrence & Slaughter, 1993; Krugman & Lawrence, 1994). European studies, on the other hand, generally view the deteriorating situation of low-skilled workers in advanced countries as being caused by the expansion of trade with less-developed countries (Wood, 1994; 1995).

18 Standard economic analysis concludes that changes in a country's pattern of trade affects its aggregate level of employment only in the short run. In the long run, macroeconomic factors act to bring employment to the level where unemployment is at its so-called "natural rate". The natural rate of unemployment is determined by the structural characteristics of labour and commodity markets such as market imperfections (e.g., minimum wages, degreee of unionization, taxes) that might prevent or impede real wages from adjusting to levels consistent with full employment. Other structural factors that might affect the natural rate are the variability of demand for, and the supply of, goods and labour; changes in mobility across occupations and regions; the cost of searching for a job; and demographic shifts. Even though unemployment may tend to return in the long run to its natural rate after exogenous changes in the volume and compostion of trade, OECD policy-makers are concerned about the effects of international trade on employment and wages in the short run.

19 Detailed results on trade and employment at the industry level are available from the authors on request.

20 These can range from physical abilities (strength, manual dexterity) to cognitive skills (analytical reasoning, mathematical and verbal abilities) and interpersonal skills (leadership, supervision) (OECD, 1996).

21 In this study, white-collar high-skilled occupations include upper-level managers, middle and other managers, professionals, technicians and associate professionals, and supervisors. White-collar low-skilled occupations include clerical, sales, and service workers. Blue-collar high-skilled occupations include foremen/women, and skilled craft and trade workers. Blue-collar low-skilled occupations include semi-skilled and manual workers, and other manual workers.

22 Here, high-skill occuaptions refer to sum of the white-collar and blue-collar high-skilled groups described earlier.

23 The decomposition procedure is as follows: $\Delta P_j = \Sigma \Delta S_i * P_{sj} + \Sigma \Delta P_{sj} * S_i$, where P_j is the proportion of high-skilled workers in total sectoral employment; S_i is the share of industry *i* in total sectoral employment; P_{sj} is the proportion of the industry's high-skilled employment in total employment; and Δ represents the average annual change.

24 The seven countries studied were the United States, Canada, Japan, France, Italy, Australia, and New Zealand. Italy was the only country where the within-industry component did not dominate the between-industry component.

25 The WWTS was conducted three times – in 1985, covering the 1980-85 period; in 1991, covering the 1986-91 period; and in 1995, covering the 1992-94 period. For more details on this survey, see McMullen (1996).

26 The occupational groups used were: managerial, professional, technical skilled, intermediate, and unskilled.

27 Note that the Labour Force Survey questions regarding educational attainment changed in January 1990. The main modification was that the list of postsecondary diplomas was extended to include a greater number of categories. The main effect of this change was that a proportion of the individuals who would normally be counted as having a high-school diploma are now counted as possessing a postsecondary diploma. As a result, caution is warranted when comparing pre-1990 with post-1990 figures.

28 Note that, following Riddell (1995), the same spacing is used for the vertical axis to permit comparisons of the steepness of the regression lines that have been fitted to the data.

29 Data for 1983 are missing because the Survey of Consumer Finances was not conducted on a large enough sample in that year.

30 The main criticism against trade being the dominant factor is that trade with developing countries remains a small part of OECD gross domestic product (OECD, 1996; Lawrence, 1994; Krugman, 1994, 1995). Other reasons against trade as the dominant factor have been advanced in the literature. These include: inconsistencies in relative price changes; changes in wages and skills in non-tradable sectors; and the fact that employment is increasingly concentrated in the non-tradable goods sectors. See OECD (1996), Lawrence (1994), and Krugman (1994) for more details.

31 As OECD (1996) argues, technology affects an industry's comparative advantage in a country and therefore affects the mix of goods that country exports and imports. At the same time, trade may accelerate the rate of technological change as an industry in one country seeks to gain a comparative advantage over another country's industry.

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

33 The model data were obtained from the productivity database. Four "industries" were excluded: postal services, other utility industries, 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 to route 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, and we have not reported them separately since they are of no interest on their own.

34 We follow the notation used in Mercier, Durand & Diaz (1991).

35 See Mercier, Durand & Diaz (1991).

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