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# Performance of Canada's Manufacturing Sector

Canada

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# Executive Summary

This Industry Canada study reviews the importance of the manufacturing sector to the Canadian economy, and assesses manufacturing industries in terms of productivity, employment, trade, investment, and production costs, as well as technology adoption, innovativeness, and connectedness.

The study has been divided into two parts. The first part analyses the presence of manufacturing industries within the Canadian economy. The second part attempts to explain the use of technologies and the undertakings of innovation and connectedness related to the performance of the individual industries described in the first part.

In order to use a consistent database in the analysis, the study examines the time frame from 1983 to 1997, the period for which the Statistics Canada data are most current. The 15-year observation period is long enough for meaningful analysis. Also, the value of manufacturing shipments and value-added used in this study are all measured in 1992 prices, eliminating the impact of inflation.

Manufacturing has grown faster than the rest of the economy. From 1983 to 1997, Gross Domestic Product (GDP) in manufacturing grew by 3.5% per year, compared to 2.7% for the economy as a whole. In terms of production share, GDP in manufacturing accounted for 16% of the total output in 1983, and this production share had increased to about 18% by 1997, more than any other sector.

Productivity is the key to a country achieving a high standard of living. The compound average annual growth of labour productivity measured by the real value of shipment per person-hour paid was 1.7% for the manufacturing sector over the period 1983 to 1997. The leading industrial groups were Electrical and Electronic Products (5.7%), Tobacco Products (3.9%), Primary Metal (3.6%), Beverage (3.4%), Primary Textile (3.2%), and Transportation Equipment (3.1%).

If labour productivity is measured by value-added per person-hour paid, then the leading industrial groups were the same as in shipment measurement, but different in ranking. They were Tobacco Products (6.1%), Electrical and Electronic Products (4.3%), Primary Textile (4.1%), Primary Metal (3.6%), Beverage (3.5%), and Transportation Equipment (3.1%). The average for the manufacturing sector was 2.2% over the period 1983 to 1997.

For regional comparison, Ontario seemed to have the highest level of labour productivity measured by the real value of shipment per person-hour paid with $130 in 1997, followed by the Prairies with $129, Quebec with $117, British Columbia with $115, and Atlantic with $103. The average for Canada was $124. In terms of annual growth rate, however, Quebec had the highest growth rate of labour productivity with 2.1% over the period 1983 to 1997, followed by Ontario with 1.9%, Atlantic with 1.7%, British Columbia with 0.7%, and Prairies with only 0.2%. The average for Canada was 1.7%.

No shipments data were available for other sectors of the economy except the manufacturing sector. Thus, for sectoral comparison, if labour productivity is defined as real GDP at factor cost per person, then the Agricultural sector had the fastest growth rate of labour productivity with 3.2% for the period 1983 to 1997, followed by Transportation, Storage and Communication with 2.7%, Manufacturing with 2.5%, Trade with 2.2%, Finance, Insurance and Real Estate with 1.3%, Utilities with 0.9%, Other Primary Industries with –0.8%, and Construction with –1.3%. The average for the national economy was 1.1%.

By using Organisation for Economic Co-operation and Development statistics, it is estimated that the growth rate of labour productivity, measured by shipment per person adjusted by a purchasing power parity (PPP) index, was 5.7% for Japan, 4.0% for the United States, 3.1% for Canada, 2.5% for France, and 0.9% for Italy over the period 1983 to 1996. In terms of level form, Canada's labour productivity, measured by shipment per person-hour adjusted for PPP, was equivalent to 59% of the US counterpart in 1996, down from 65% in 1983.

To cope with the Free Trade Agreement and the North American Free Trade Agreement, Canada's manufacturing sector has adopted a cost reduction measure by reducing workforce over the period 1988 to 1994. The study also found that employment in the manufacturing sector is more sensitive than the non-manufacturing sector in response to economic boom and bust.

Most industrial groups within the manufacturing sector have increased labour productivity by reducing administrative employees. This is especially significant for high-tech industries, such as Electrical and Electronic Products, Transportation Equipment, Refined Petroleum and Coal, Chemical, and Machinery.

A strong correlation did exist between labour productivity and establishment employment size for the high-tech industries, such as Electrical and Electronic Products, Transportation Equipment, and Machinery, over the period 1983 to 1997.

In 1996, 39% of manufacturing output was exported. The most export-oriented industries were Paper and Allied Products (62%), Transportation Equipment (61%), Electrical and Electronic Products (59%), Wood (49%), and Machinery (47%). Tobacco Products (5%), Printing, Publishing, and Allied Industries (8%), Refined Petroleum and Coal Products (11%), Food (14%), Clothing (15%), and Beverage (16%) tend to serve the domestic market.

The study also analysed the cost components of the manufacturing sector. In general, wages and salaries, and energy and fuel costs fell relative to shipments, while materials and supplies costs increased at about the same pace as shipments over the period 1983 to 1997.

There appears to be a significant relation between capital intensity and labour productivity growth. Of the nine industries with above average productivity growth over the period 1983 to 1997, all but one (Rubber Products) had an above average increase in the capital/labour ratio. However, there appears to be no relationship between labour productivity growth and the ratio of capital stock to shipments.

The study then turns to the use of advanced technologies in the manufacturing sector. Two Statistics Canada surveys, one looking at 1993, the other at 1998, were used predominantly in this examination. The study did confirm that those industries leading in technology adoption in the manufacturing sector would see an acceleration of their labour productivity. For instance, the leading industries of technology adoption in the 1998 survey were Beverage, Primary Textile, Paper and Allied Products, Primary Metal, and Electrical and Electronic Products. These five industries were also the leading industries of labour productivity growth both in the measurement of shipments or value-added.

The five most important technologies adoption in both 1993 and 1998 surveys were: Computer Aided Design/Engineering, Programmable Controllers, Factory Computers, Technical LANs and Inter-Company Networks. Connectedness is also an important innovation. According to the 1998 survey, half of manufacturing plants had adopted at least one type of advanced network communication technology.

Studies looked at for this report make it clear that innovation pays off. Over the 1994 to 1997 period, the most innovative Canadian firms averaged growth of 4.7% per year compared to 2.3% growth for those with the lowest level of innovation.

Canadian regions show distinct differences in adoption of technology products. Ontario tends to have the highest adoption levels, followed by Prairies, Quebec, Atlantic, and British Columbia. Overall, however, the adoption figures by region tend to be quite close to the Canadian average.

In terms of barriers to innovation, firms identify the high cost of equipment and the cost of capital. Surveys also show that about two thirds of technology users have experienced a shortage of skilled personnel.

The study concludes by identifying the key issues facing the manufacturing sector. Some of the factors that enhance productivity growth are highlighted, along with a discussion on how to encourage more innovation and adoption of technology by manufacturing firms.

# Introduction

The manufacturing sector plays an important role in the Canadian economy. It contributes significantly to the Gross Domestic Product (GDP), employment, gross fixed capital formation, merchandise exports, and the use of advanced technologies.

The main purpose of this study is to assess the performance of the manufacturing sector in the areas of shipments, employment, trade, investment, production cost, as well as technology adoption, innovation and connectedness during the period 1983 to 1997. It also examines the major challenges the sector will face in the future.

The study is divided into two parts. Part One contains seven sections, each of which outlines a different thread related to the performance of Canada's manufacturing sector. Although they are described separately, in fact they work together and are mutually illuminating.

The presence of manufacturing industries within the Canadian economy is analysed in the first section. Section II presents the labour productivity performance of manufacturing industries. Section III takes a look at labour productivity from an international perspective. Employment performance in manufacturing industries and destinations of manufacturing shipments are analysed in sections IV and V. Section VI examines the evolving production costs in the manufacturing sector. The last section of Part One, Section VII, analyses capital investment by industrial group.

The analysis presented in Part Two attempts to explain the similarities and differences found in the performance of the individual industries described in Part One. Section VIII reports the use of advanced technologies by industrial groups. Section IX summarizes connectedness in manufacturing, while Section X discusses innovation in the manufacturing sector. Human capital issues in manufacturing are discussed in Section XI. Section XII presents concluding remarks and major challenges faced by the manufacturing sector.

Three appendices provide context to the discussion.

# Part ONE

## Contribution of the Manufacturing Sector to the Economy

### Scope of the Sector

Statistics Canada has revised the Standard Industrial Classification (SIC) three times – in 1960, 1970 and 1980, due to expansion of industries in the economy. In each revision, new industries were added, or an industrial group was disaggregated into more industrial groups. Therefore, the contents of industries in the manufacturing sector in each revision are different from each other.

Subsequent data collection by Statistics Canada was then based on new industrial classifications. The results of these SIC changes have caused data inconsistency for a few industries.

Statistics Canada, however, did publish principal statistics such as shipments, value-added, wages, energy costs, material costs, employment, and number of establishments for the manufacturing sector for three periods of time:

- 1961 to 1971 data on the basis of 1960 SIC;
- 1972 to 1982 data under the 1970 SIC; and
- 1983 to 1997 data under the 1980 SIC.

In order to use a consistent database in our analysis of performance of the manufacturing sector, we used the data collected between 1983 and 1997. The reason for choosing this period is that the data are most current and the observation period is long enough to undertake a meaningful analysis.

According to the 1980 revision of the SIC, there are currently 22 industrial groups under the manufacturing sector. The following are those 22 industrial groups corresponding to two-digit SICs:

### Contents of Manufacturing Sector

| SIC Code | Major Industry Group |
|---|---|
| 10 | Food industries |
| 11 | Beverage industries |
| 12 | Tobacco products industries |
| 15 | Rubber products industries |
| 16 | Plastic products industries |
| 17 | Leather and allied products industries |
| 18 | Primary textile industries |
| 19 | Textile products industries |
| 24 | Clothing industries |
| 25 | Wood industries |
| 26 | Furniture and fixture industries |
| 27 | Paper and allied products industries |
| 28 | Printing, publishing and allied industries |
| 29 | Primary metal industries |
| 30 | Fabricated metal products industries |
| 31 | Machinery industries |
| 32 | Transportation equipment industries |
| 33 | Electrical and electronic products industries |
| 35 | Non-metallic mineral products industries |
| 36 | Refined petroleum and coal products industries |
| 37 | Chemical and chemical products industries |
| 39 | Other manufacturing industries |

### Contribution to Gross Domestic Product

To properly assess the contribution of manufacturing industries to the total economy, we used the real GDP at factor cost by industry. As manufacturing is part of the goods-producing industries group, we examined the importance of the manufacturing sector in both the goods-producing industries as well as the total economy.

As Table 1 indicates, the manufacturing sector accounted for 17% of the real GDP in 1961, and this production share had increased slightly to 18% by 1998. If we look at the goods-producing industries in the same time frame, the manufacturing sector's production share has increased much faster, from 43% to 54%. The compound annual growth rate for the manufacturing sector was about 3.6% between 1961 and 1998, compared with 3.0% for the goods-producing industries and 3.5% for the GDP.

**Table 1: Contribution of Manufacturing Sector to GDP at Factor Cost in 1992 Prices (millions of dollars)**

| Year | Manufacturing Sector (1) | Goods-producing Industries (2) | Gross Domestic Product (3) | Share of Manufacturing to Goods-producing Industries (4)=(1)/(2) % | Share of Manufacturing to Gross Domestic Product (5)=(1)/(3) % |
|---|---|---|---|---|---|
| 1961 | 34,249 | 79,718 | 199,053 | 43.0 | 17.2 |
| 1970 | 58,163 | 123,434 | 314,948 | 47.1 | 18.5 |
| 1980 | 82,165 | 168,955 | 469,180 | 48.6 | 17.5 |
| 1990 | 102,570 | 206,725 | 609,231 | 49.6 | 16.8 |
| 1998 | 127,912 | 235,944 | 717,562 | 54.2 | 17.8 |
| Compound Annual Growth Rate 1961–1998 (%) | 3.6 | 3.0 | 3.5 | – | – |

Source: Statistics Canada. *Canadian Economic Observer: Historical Statistical Supplement,*1999.

## Manufacturing Shipment Trends

By examining the value of shipments of the manufacturing sector, we see that it has generally moved similarly to the value of GDP from 1983 to 1997, as shown in Figure 1. However, the swings in manufacturing output tend to be more dramatic where both positive or negative, indicating that the manufacturing sector performed much worse than the general economy during the period of recession and performed much better during recovery. Figure 2 illustrates a comparison of growth rates for GDP and manufacturing shipments. Given this volatility, the value of manufacturing shipments increased at an average annual rate of 3.0% while real GDP grew at 2.8%.

Table 2 indicates that of the 22 industrial groups, 14 exhibited shipment growth of less than 3% per year on average, and only the Leather and Allied Products, and Refined Petroleum and Coal Products experienced a decline in the value of shipments, –4.6% and –0.1% per year respectively between 1983 and 1997. The other eight industrial groups with average annual growth rates higher than the sector average ranged from Rubber Products with 6.5% down to Primary Metal with 3.3%.

**Figure 1: Value of Manufacturing Shipments and GDP at 1992 Prices (billions of dollars)**

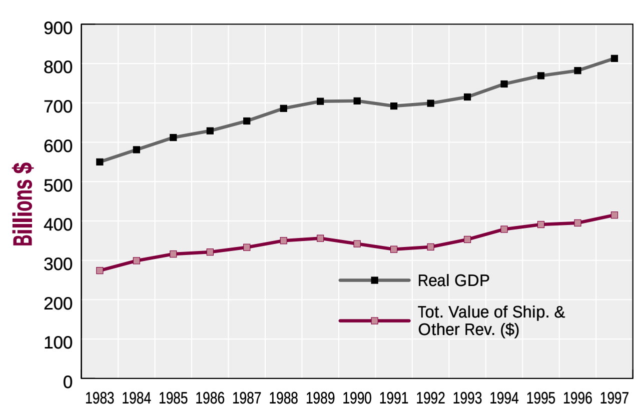



**Figure 2: Comparison of Annual Growth Rates for GDP and Manufacturing Shipments**

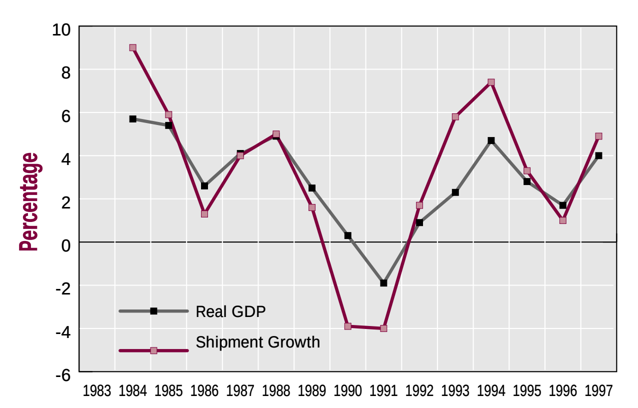


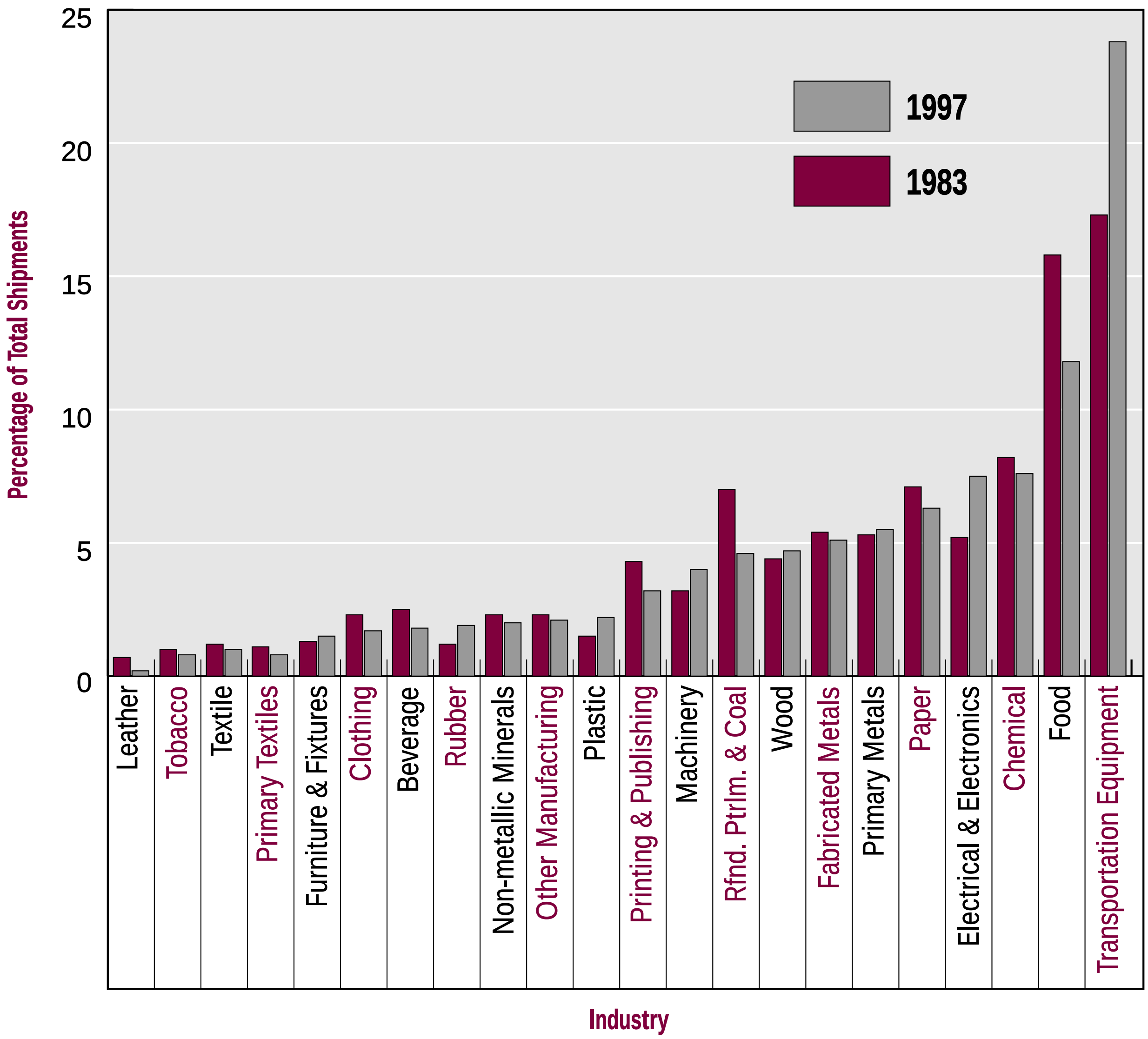
**Table 2: Comparison of Manufacturing Industries' Shipments: Based on 1992 Prices (millions)**

| Industries by 2-Digit SIC Level | Year 1983 | 1990 | 1997 | Average Annual Growth Rate 1983–1997 (%) | Average Annual Labour Productivity Growth Rate (%) |
|---|---|---|---|---|---|
| Food | 43,400 | 46,691 | 49,129 | 0.89 | 0.10 |
| Beverage | 6,748 | 6,252 | 7,394 | 0.66 | 3.40 |
| Tobacco | 2,780 | 3,368 | 3,461 | 1.58 | 3.90 |
| Rubber | 3,245 | 3,813 | 7,796 | 6.46 | 2.30 |
| Plastic | 4,031 | 6,357 | 9,220 | 6.09 | 0.10 |
| Leather & Allied | 1,860 | 1,351 | 967 | -4.57 | 1.00 |
| Primary Textiles | 3,307 | 3,096 | 3,970 | 1.31 | 3.20 |
| Textiles | 3,102 | 3,686 | 3,470 | 0.80 | 1.10 |
| Clothing | 6,372 | 7,670 | 7,030 | 0.70 | 2.40 |
| Wood | 12,019 | 16,501 | 19,456 | 3.50 | 1.20 |
| Furniture & Fixtures | 3,679 | 4,926 | 6,096 | 3.67 | 1.00 |
| Paper & Allied Products | 19,547 | 21,625 | 26,199 | 2.11 | 2.20 |
| Printing & Publishing | 11,766 | 15,120 | 13,193 | 0.82 | -0.60 |
| Primary Metal | 14,526 | 17,658 | 22,801 | 3.27 | 3.60 |
| Fabricated Metal | 14,772 | 19,308 | 21,216 | 2.62 | -0.10 |
| Machinery | 8,884 | 12,261 | 16,839 | 4.67 | 1.30 |
| Transportation Equipment | 47,475 | 73,810 | 98,718 | 5.37 | 3.10 |
| Electrical & Electronics | 14,360 | 21,429 | 31,034 | 5.66 | 5.70 |
| Non-metallic Mineral | 6,319 | 8,408 | 8,379 | 2.04 | 1.30 |
| Refined Petroleum & Coal | 19,148 | 17,216 | 18,911 | -0.09 | 1.40 |
| Chemical | 22,456 | 27,144 | 31,489 | 2.44 | 1.50 |
| Other Manufacturing | 6,386 | 7,286 | 8,873 | 2.38 | 1.00 |
| **Total Manufacturing** | **274,095** | **341,982** | **414,634** | **3.00** | **1.70** |

Source: Statistics Canada.

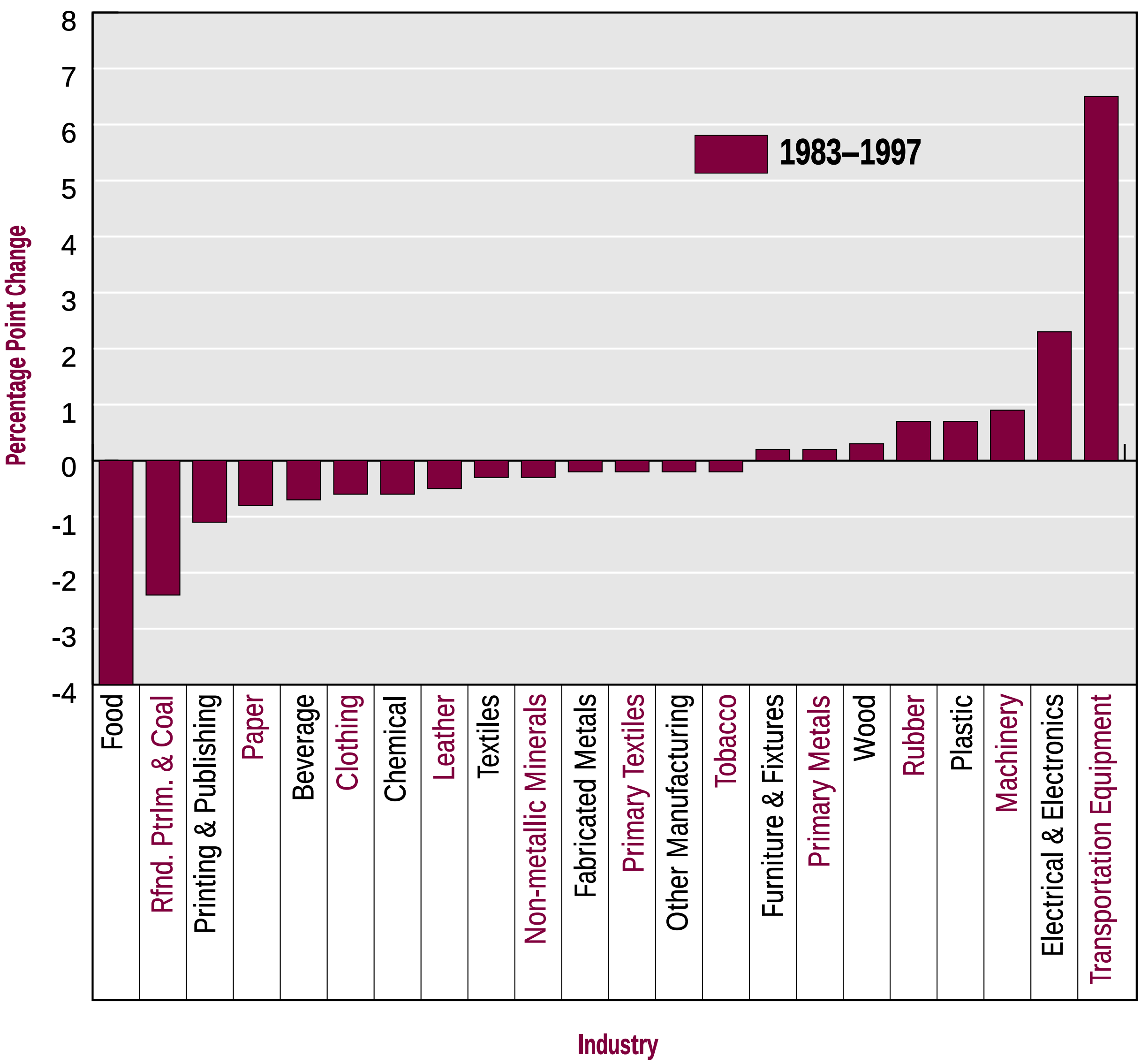
As shown in Figures 3 and 4, a result of these output trends indicated that Furniture and Fixtures, Primary Metals, Wood, Rubber Products, Plastic Products, Machinery, Electrical and Electronic Products, and Transportation Equipment all increased their share of total manufacturing shipment values by up to one percentage point between 1983 and 1997. Electrical and Electronic Products, and Transportation Equipment registered the two largest and most significant increases, rising 2.2 and 6.5 percentage points respectively by 1997.

**Figure 3: Share of Total Manufacturing Shipments by Industrial Group**




Source: Statistics Canada Based on Establishment's Total Activity.

**Figure 4: Changes in Shares of Total Manufacturing Shipments by Industry (1983 vs 1997)**




Source: Statistics Canada Based on Establishment's Total Activity.

## Labour Productivity Performance in the Manufacturing Sector

### Current Ranking in the World

Productivity is the most important determinant of a country's standard of living; high productivity is key to a high standard of living. By international standards, Canada is doing relatively well, displaying both high productivity levels and a high standard of living.

According to *The World Competitiveness Yearbook*, published by the Institute for Management Development of Switzerland in April 1999, Canada's overall labour productivity, measured in GDP (purchasing power parity) per employee per hour, was ranked 14th in the world in 1998 with US$26.22. Among G-7 countries, Canada fell behind France with US$33.66, Italy with $31.99, US with US$31.28 and Germany with US$28.94, but was ahead of Japan with US$25.73 and the United Kingdom with US$24.84. By this measure, Canada's labour productivity is about 28% lower than that of France, 22% lower than Italy, 19% lower than the United States and 10% lower than Germany, but 2% higher than Japan and 5% higher than the United Kingdom.

In terms of standard of living measured by the GDP per capita in US dollars at current prices and exchange rates, Canada was ranked 20th in the world in 1998 with US$19,627, the lowest among G-7 countries. Among the G-7, the United States has the highest GDP per capita with US$31,451, followed by Japan with US$30,164, Germany with US$25,758, France with US$24,107, the United Kingdom with US$23,266 and Italy with US$20,130. By this measure, the United States' GDP per capita was more than 60% higher than that of Canada in 1998.

Although Canada was the ninth largest economy in the world in 1998 with US$595 billion, next to the United States (US$8,509 B), Japan (US$3,786 B), Germany (US$2,118 B), France (US$1,419 B), the United Kingdom (US$1,378 B), Italy (US$1,161 B), China (US$961 B), and Brazil (US$777 B), our GDP per capita is not matched with our total economy ranking. This suggests that our productivity performance leaves much room to be improved. Faster productivity growth is the essential factor to maintaining and improving living standards.

## Productivity Measures

Normally, productivity measures how much output is produced relative to the inputs of labour, capital and technical progress. It can be measured on a firm, industry or country basis. Increased productivity means that more output can be produced with the same input, or perhaps less input.

In practice, there are two main types of productivity measures: labour productivity, and total factor productivity (TFP) or multi-factor productivity. Labour productivity is a partial factor productivity because it is confined to measure output performance by the labour input only. TFP provides a broader measure of productivity by evaluating the contribution of not only labour, but all other inputs to production.

However, because of drawbacks associated with TFP (see Appendix 1), this study is confined to investigate labour productivity in Canada's manufacturing sector. Labour productivity is typically expressed as output per hour or output per worker; it is derived by dividing real output by a measure of labour input. Labour input is best measured by total person hours paid, which accounts for changes over time in the part-time and full-time split of the workforce. Person hours paid therefore provides a more accurate representation of labour productivity trends. The definition of labour productivity used in this study is expressed in the following formula:

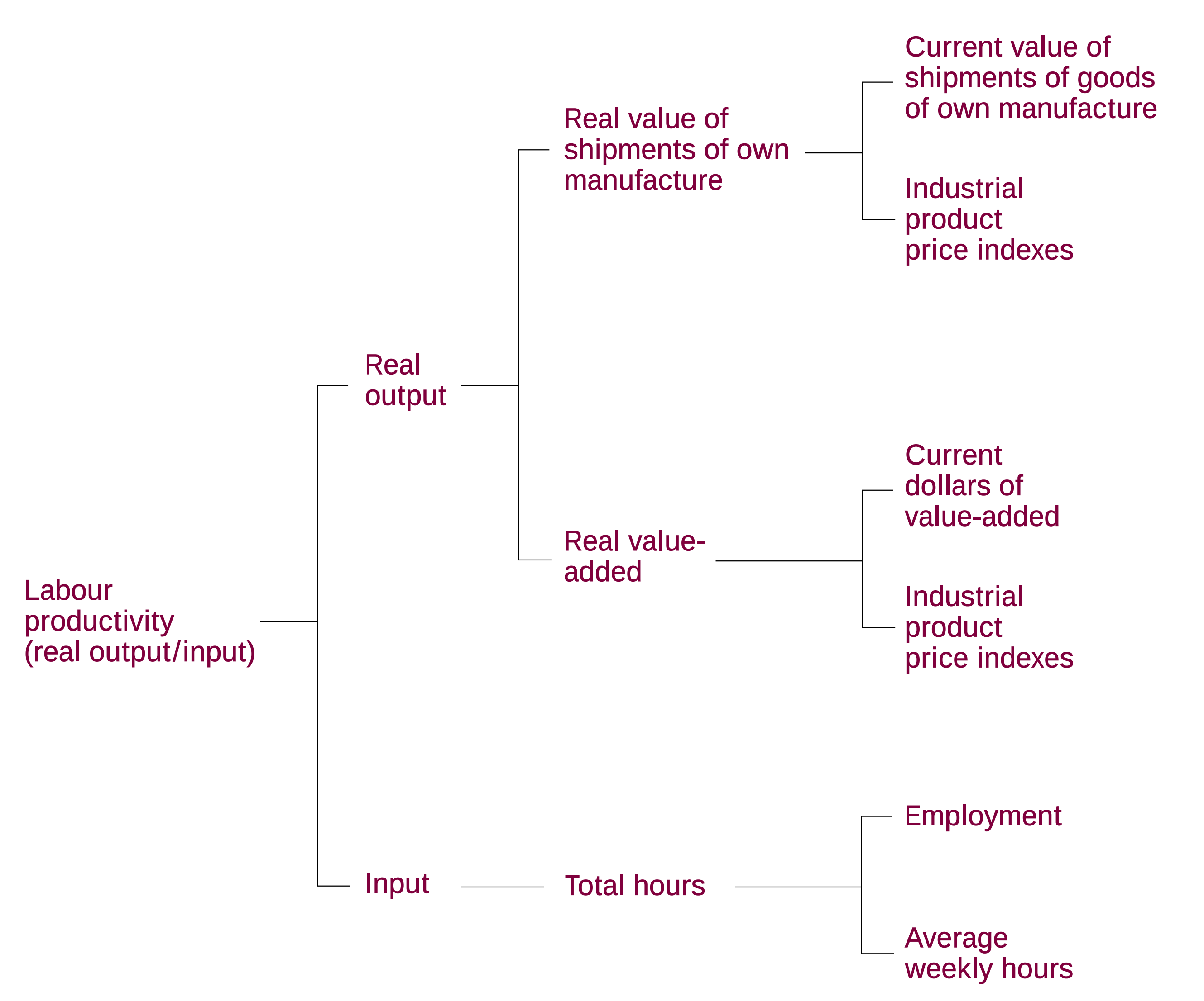
$$\text{Labour productivity} = \frac{\text{Real value of shipments of goods of own manufacture}}{\text{Total person-hours paid}}$$

For industrial comparison, labour productivity can also be expressed in real value-added terms:

$$\text{Labour productivity} = \frac{\text{Real value-added of goods of own manufacture}}{\text{Total person-hours paid}}$$

In its report on principal statistics by major group and industry, Statistics Canada publishes value of manufacturing shipments in two different types: one based on manufacturing activity, the other on total activity. Manufacturing activity is limited solely to the value of shipments of goods of own manufacture; total activity includes value of shipments and other revenue. To reflect the true labour productivity performance, it is more appropriate to use value of shipments of goods of own manufacture as output. To eliminate the impact of inflation, we use real labour productivity measurement rather than current dollars. Both value of shipments of goods of own manufacture and value-added are divided by industrial product price indexes. Figure 5 indicates the building blocks of labour productivity.

**Figure 5: Information Flows of Labour Productivity**




### Labour Productivity Levels

By definition, labour productivity is measured either in shipments per hour worked or value-added per hour worked. Table 3 indicates that for the manufacturing sector as a whole, its labour productivity measured in value of shipments had increased (based on 1992 prices) from about $98 per hour in 1983 to about $124 per hour by 1997. However, the magnitudes of labour productivity vary substantially among different industrial groups. For instance, Clothing had the lowest value of labour productivity with only $44 per hour, compared with $1,393 per hour for Refined Petroleum and Coal Products in 1997.

If labour productivity is measured in value-added, again Clothing had the lowest value of labour productivity with about $23 per hour, compared with Tobacco Products which had the highest value with $334 per hour in 1997. The reasons underlying substantial differences in labour productivity levels among manufacturing industries are likely due to the different nature of manufacturing products, educational attainment of workers, and capital stock required by the industries.

Generally, manufacturing of products requiring minimum education and low capital investment also have low value of labour productivity, such as Plastic Products, Leather and Allied Products, Textile Products,

**Table 3: Comparison of Labour Productivity in the Manufacturing Sector at 1992 Prices (shipments per hour worked)**

| Industries by 2-Digit SIC Level | Year 1983 | 1990 | 1997 | Growth Rate 1983–1997 (%) |
|---|---|---|---|---|
| Food | 138.38 | 134.66 | 139.92 | 0.1 |
| Beverage | 167.27 | 206.49 | 265.98 | 3.4 |
| Tobacco | 292.39 | 439.66 | 498.12 | 3.9 |
| Rubber | 68.03 | 71.42 | 93.03 | 2.3 |
| Plastic | 73.94 | 67.12 | 74.72 | 0.1 |
| Leather & Allied | 40.07 | 41.65 | 45.81 | 1.0 |
| Primary Textile | 64.54 | 83.07 | 100.38 | 3.2 |
| Textiles | 55.91 | 54.75 | 65.54 | 1.1 |
| Clothing | 31.34 | 38.62 | 43.94 | 2.4 |
| Wood | 67.63 | 76.92 | 80.33 | 1.2 |
| Furniture & Fixtures | 48.06 | 43.97 | 55.18 | 1.0 |
| Paper & Allied | 104.17 | 114.08 | 140.30 | 2.2 |
| Printing & Publishing | 88.83 | 84.66 | 81.21 | -0.6 |
| Primary Metal | 88.91 | 109.57 | 145.53 | 3.6 |
| Fabricated Metal | 67.53 | 62.46 | 66.21 | -0.1 |
| Machinery | 80.63 | 81.34 | 96.70 | 1.3 |
| Transportation Equipment | 125.07 | 148.35 | 190.81 | 3.1 |
| Electrical & Electronic | 72.64 | 93.82 | 157.15 | 5.7 |
| Non-metallic Mineral | 82.21 | 78.94 | 98.62 | 1.3 |
| Refined Petroleum & Coal | 1,144.93 | 1,149.34 | 1,392.58 | 1.4 |
| Chemical | 197.28 | 215.72 | 242.01 | 1.5 |
| Other Manufacturing | 56.85 | 53.21 | 65.15 | 1.0 |
| **Total Manufacturing** | **97.91** | **102.70** | **124.20** | **1.7** |

Clothing, Wood, Printing, Publishing and Allied, and Fabricated Metal Products. On the contrary, manufacturing products demanding high labour skills and capital intensity have relatively high value of labour productivity, such as Refined Petroleum and Coal Products, Electrical and Electronic Products, Transportation Equipment, Chemical and Chemical Products, Beverage, and Tobacco Products.

### Labour Productivity Growth Rates

Based on the aforementioned formula, we computed labour productivity, measured by constant dollars of shipments per hour worked, for the 22 two-digit industrial groups and the total manufacturing sector.

The results are presented in Table 3. During the past 15 years, with the exceptions of Printing, Publishing and Allied, and Fabricated Metal Products, the other 20 industries have registered positive growth of labour productivity, ranging from 0.1% for Food and Plastic Products to 5.7% for Electrical and Electronic Products. The average annual growth rate for the manufacturing sector between 1983 and 1997 was 1.7%. The following nine industrial groups had corresponding growth rates higher than the average: Electrical and Electronic Products (5.7%), Primary Textile Products (3.2%), Tobacco Products (3.9%), Primary Metal (3.6%), Beverage (3.4%), Transportation Equipment (3.1%), Clothing (2.4%), Rubber Products (2.3%), and Paper and Allied Products (2.2%).

The growth rates for the following 13 industrial groups were all below the average: Chemical and Chemical Products (1.5%), Refined Petroleum and Coal Products (1.4%), Machinery, and Non-metallic Mineral Products (1.3%), Wood (1.2%), Textile Products (1.1%), Leather and Allied Products, Furniture and Fixtures, and Other Manufacturing (1.0%), Food, and Plastic Products (0.1%), followed by Fabricated Metal Products (–0.1%), and Printing, Publishing and Allied (–0.6%).

As shown in Table 4, if labour productivity is measured by value-added, rather than value of shipments, then value-added per hour worked for the overall manufacturing sector had increased from $37 per hour in 1983 to about $50 per hour by 1997 (in 1992 prices), suggesting an average annual growth rate of 2.2%, about half a percentage point higher than that of shipments per hour.

By examining all 22 two-digit manufacturing groups, nine have corresponding growth rates higher than the average: Tobacco Products (6.1%), Electrical and Electronic Products (4.3%), Primary Textile (4.1%), Primary Metal (3.6%), Beverage (3.5%), Transportation Equipment (3.1%), Paper and Allied Products (2.8%), Chemical and Chemical Products (2.6%), and Clothing (2.3%).

**Table 4: Comparison of Labour Productivity in the Manufacturing Sector at 1992 Prices (value-added per hour worked)**

| Industries by 2-Digit SIC Level | Year 1983 | Year 1990 | Year 1997 | Growth Rate 1983–1997 (%) |
|---|---|---|---|---|
| Food | 39.97 | 45.81 | 45.20 | 0.9 |
| Beverage | 97.91 | 122.37 | 158.05 | 3.5 |
| Tobacco | 145.77 | 262.32 | 333.96 | 6.1 |
| Rubber | 32.56 | 36.59 | 41.67 | 1.8 |
| Plastic | 32.20 | 30.89 | 35.40 | 0.7 |
| Leather & Allied | 20.04 | 19.65 | 21.25 | 0.4 |
| Primary Textile | 27.22 | 37.65 | 47.67 | 4.1 |
| Textile | 24.71 | 23.09 | 29.34 | 1.2 |
| Clothing | 16.26 | 19.44 | 22.46 | 2.3 |
| Wood | 28.35 | 29.35 | 30.33 | 0.5 |
| Furniture & Fixtures | 25.02 | 22.92 | 27.98 | 0.8 |
| Paper & Allied | 41.15 | 49.74 | 60.51 | 2.8 |
| Printing & Publishing | 56.33 | 53.93 | 51.36 | –0.7 |
| Primary Metal | 35.86 | 42.48 | 58.97 | 3.6 |
| Fabricated Metal | 32.13 | 30.32 | 32.89 | 0.2 |
| Machinery | 39.70 | 39.50 | 47.13 | 1.2 |
| Transportation Equipment | 40.55 | 45.68 | 61.73 | 3.1 |
| Electrical & Electronic | 37.13 | 46.31 | 67.28 | 4.3 |
| Non-metallic Mineral | 42.10 | 40.97 | 52.14 | 1.5 |
| Refined Petroleum & Coal | 129.11 | 167.36 | 150.08 | 1.1 |
| Chemical | 78.28 | 105.73 | 111.67 | 2.6 |
| Other Manufacturing | 28.16 | 28.14 | 35.94 | 1.8 |
| **Total Manufacturing** | **37.02** | **42.25** | **49.93** | **2.2** |

Among these nine high labour productivity growth manufacturing industries, eight have the same labour productivity measured in shipments per hour worked. The other industrial group is Chemical and Chemical Products, which appears to have a higher growth rate in value-added measurement than in shipments.

The other 13 manufacturing industries with growth rates below the average are: Rubber Products, and Other Manufacturing (1.8%), Non-metallic Mineral Products (1.5%), Textile Products, and Machinery (1.2%), Refined Petroleum and Coal Products (1.1%), Food (0.9%), Furniture and Fixtures (0.8%), Plastic Products (0.7%), Wood (0.5%), Leather and Allied Products (0.4%), Fabricated Metal Products (0.2%), and Printing, Publishing and Allied (–0.7%).

In terms of growth rate rankings, the labour productivity measured either in shipments per hour worked or in value-added per hour worked are more or less the same. The results also indicated that Printing, Publishing and Allied appears to be the only group that experienced negative growth on both counts between 1983 and 1997.

### Labour Productivity Trends

To estimate time trends for shipments and value-added per hour worked at 1992 prices during the period 1983 to 1997, we used a simple linear regression defined as:

$$Y = a + b \times T$$

Where:

Y = labour productivity measures
T = Time (1983 = 1, ..., 1997 = 15)
Estimation period 1983–1997

In the case of productivity measured in shipment data at 1992 prices, the results in Table 5 indicate that 18 industrial groups experienced strong labour productivity growth between 1983 and 1997. Only Printing, Publishing and Allied Products showed a strong decline of its productivity growth. Labour productivity for Fabricated Metal Products, Food, and Plastic Products was relatively stable during this time frame, as the time trend was not statistically significant.

If labour productivity is measured in value-added at 1992 prices, the results of time trend regression are similar to those of the shipments case shown in Table 5. Again, Printing, Publishing and Allied experienced a strong decrease of its productivity growth. Fabricated Metal Products, Leather and Allied Products, and Wood have showed an insignificant increase of their labour productivity, and the other 18 industrial groups all experienced a strong trend of productivity growth during the period 1983 to 1997.

If we estimate labour productivity in current dollars for the period 1983 to 1997, it is interesting to note that labour productivity for all 22 industrial groups has indicated a statistically significant time trend, with the exception of Refined Petroleum and Coal Products, which now shows an insignificant trend of growth. The regression results are presented in Table 6.

### Regional Comparison of Labour Productivity

This section will compare labour productivity for Atlantic, Quebec, Ontario, Prairies, and British Columbia regions. Due to statistical confidentiality problems, some industrial groups will be excluded. The confidentiality problem is more serious in the Prairies and the Atlantic regions: the former has 11 industrial groups excluded, and the latter 16 industries. Details of exclusion are presented in Table 7.

For the manufacturing sector as a whole, Ontario appears to have the highest level of labour productivity per person-hour worked with $130 in 1997, followed by the Prairies with $129, Quebec with $117, British Columbia with $115, and the Atlantic with $103. Regional differences in labour productivity levels are likely due to regional differences in cost of living, industrial structure, technology use, and employment opportunities.

The Prairies enjoyed the highest labour productivity level in Canada in the 1980s and early 1990s, and it was only recently taken over by Ontario. Their high level of labour productivity has been attributed to the relatively high performance of Chemical and Chemical Products, Electrical and Electronic Products, and Food industries.

In Atlantic Canada, only six industrial groups – Chemical and Chemical Products, Electrical and Electronic Products, Fabricated Metal Products, Machinery, Printing, Publishing and Allied, and Wood – are not restricted by the data confidentiality problem. It is interesting to note that these six industries' labour productivity levels were consistently lower than the national average levels during the period 1983 to1997.

**Table 5: Canadian Manufacturing Labour Productivity Time Trend Estimates, 1983 to1997 (based on constant 1992 dollars)**

| Industries by | Productivity Based on Shipment Data | | | | | Productivity Based on Value-Added Data | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2-Digit SIC Level | Constant | T-Stat | Time Trend | T-Stat | R-Squ. Adj. | Constant | T-Stat | Time Trend | T-Stat | R-Squ. Adj. |
| Beverage | 144.6 | 34.8 | 7.76 | 17.0 | 0.95 | 81.1 | 20.8 | 5.04 | 11.7 | 0.91 |
| Chemical | 197.7 | 48.3 | 2.27 | 5.1 | 0.64 | 83.9 | 29.6 | 2.14 | 6.9 | 0.77 |
| Clothing | 29.2 | 47.5 | 1.11 | 16.4 | 0.95 | 14.9 | 39.6 | 0.54 | 13.1 | 0.92 |
| Electrical & Electronic | 57.4 | 12.6 | 6.10 | 12.1 | 0.91 | 33.7 | 19.8 | 1.70 | 9.1 | 0.85 |
| Fabricated Metal | 65.5 | 37.4 | 0.02 | 0.1 | –0.08 | 30.6 | 28.4 | 0.17 | 1.4 | 0.14 |
| Food | 137.0 | 86.9 | 0.06 | 0.3 | –0.07 | 41.0 | 33.7 | 0.44 | 3.3 | 0.41 |
| Furniture & Fixtures | 42.9 | 25.7 | 0.64 | 3.5 | 0.45 | 22.1 | 21.7 | 0.34 | 3.0 | 0.38 |
| Leather & Allied | 39.4 | 63.4 | 0.30 | 4.4 | 0.57 | 19.4 | 34.1 | 0.08 | 1.2 | 0.03 |
| Machinery | 72.6 | 21.1 | 1.32 | 3.5 | 0.45 | 35.6 | 18.1 | 0.67 | 3.1 | 0.38 |
| Non-metallic Mineral | 78.0 | 29.1 | 0.93 | 3.2 | 0.39 | 40.2 | 25.6 | 0.57 | 3.3 | 0.41 |
| Other Manufacturing | 52.8 | 27.7 | 0.75 | 3.6 | 0.46 | 25.1 | 18.5 | 0.76 | 5.1 | 0.64 |
| Paper & Allied | 100.0 | 36.4 | 2.72 | 9.0 | 0.85 | 43.3 | 13.7 | 1.15 | 3.3 | 0.42 |
| Plastic | 69.6 | 37.6 | 0.18 | 0.9 | -0.01 | 30.0 | 29.0 | 0.29 | 2.6 | 0.29 |
| Primary Metal | 85.3 | 29.4 | 3.76 | 11.8 | 0.91 | 36.3 | 25.9 | 1.33 | 8.6 | 0.84 |
| Primary Textiles | 65.2 | 45.8 | 2.19 | 14.0 | 0.93 | 27.9 | 27.4 | 1.25 | 11.1 | 0.90 |
| Printing, Publishing & Allied | 91.1 | 64.1 | –0.72 | –4.6 | 0.59 | 56.8 | 42.3 | –0.40 | –2.7 | 0.31 |
| Refined Petroleum & Coal | 1035.0 | 18.6 | 17.60 | 2.9 | 0.34 | 123.4 | 10.4 | 3.12 | 2.4 | 0.25 |
| Rubber | 63.8 | 22.5 | 1.81 | 5.8 | 0.7 | 32.4 | 25.9 | 0.67 | 4.9 | 0.62 |
| Transportation Equipment | 109.5 | 22.5 | 5.02 | 9.4 | 0.86 | 35.3 | 18.2 | 1.38 | 6.5 | 0.75 |
| Wood | 70.4 | 56.9 | 0.80 | 5.9 | 0.7 | 30.0 | 26.1 | 0.15 | 1.2 | 0.03 |
| Textiles | 52.5 | 38.8 | 0.81 | 5.4 | 0.67 | 22.3 | 26.4 | 0.44 | 4.7 | 0.6 |
| Tobacco | 305.5 | 16.1 | 12.73 | 6.1 | 0.72 | 140.1 | 10.6 | 12.68 | 8.7 | 0.84 |
| **Total Manufacturing** | **90.2** | **35.9** | **2.20** | **7.9** | **0.82** | **35.5** | **51.0** | **0.97** | **12.7** | **0.92** |

The results in Table 8 show regional growth rates of labour productivity in the overall manufacturing sector between 1983 and 1997. Quebec registered the fastest growth with a compound annual growth rate of 2.1%, followed by Ontario with 1.9%, Atlantic with 1.7%, British Columbia with 0.7%, and Prairies with only 0.2%. The national average was 1.7%. For individual industrial groups, productivity growth for Electrical and Electronic Products performed remarkably throughout the regions. Transportation Equipment, and Beverage also showed a strong growth in labour productivity in four regions, with the exception of Atlantic.

## Sectoral Comparison of Labour Productivity in the National Economy

The manufacturing sector is one of the key components within the Canadian economy. As such, it is of great interest to compare the performance of the manufacturing sector in the area of labour productivity with other components of the national economy. A comparison of labour productivity in shipments per hour worked is not possible, since Canada has no comparable statistics on value of shipments and person-hours paid which are associated with other components of the economy.

**Table 6: Canadian Manufacturing Labour Productivity Time Trend Estimates, 1983 to 1997 (based on current dollars)**

| Industries by | Productivity Based on Shipment Data | | | | | Productivity Based on Value-Added Data | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2-Digit SIC Level | Constant | T-Stat | Time Trend | T-Stat | R-Squ. Adj. | Constant | T-Stat | Time Trend | T-Stat | R-Squ. Adj. |
| Beverage | 13.2 | 2.3 | 1.58 | 33.4 | 0.99 | 51.7 | 13.5 | 7.93 | 18.8 | 0.96 |
| Chemical | 155.4 | 22.0 | 7.78 | 10.0 | 0.88 | 65.5 | 15.2 | 4.62 | 9.7 | 0.87 |
| Clothing | 22.8 | 38.4 | 1.75 | 26.7 | 0.98 | 11.6 | 32.3 | 0.87 | 22.0 | 0.97 |
| Electrical & Electronic | 44.3 | 9.0 | 7.73 | 14.2 | 0.94 | 27.5 | 16.0 | 2.44 | 12.9 | 0.92 |
| Fabricated Metal | 51.5 | 28.7 | 1.76 | 8.9 | 0.85 | 23.8 | 22.0 | 1.02 | 8.6 | 0.84 |
| Food | 107.5 | 54.5 | 3.46 | 16.0 | 0.95 | 32.0 | 35.2 | 1.49 | 14.9 | 0.94 |
| Furniture & Fixtures | 30.7 | 22.1 | 1.97 | 12.9 | 0.92 | 15.8 | 18.3 | 1.03 | 10.9 | 0.89 |
| Leather & Allied | 26.4 | 41.3 | 1.66 | 23.7 | 0.98 | 13.1 | 28.8 | 0.73 | 14.6 | 0.94 |
| Machinery | 50.4 | 13.8 | 3.69 | 9.2 | 0.86 | 24.7 | 12.5 | 1.84 | 8.5 | 0.84 |
| Non-metallic Mineral | 62.5 | 23.4 | 2.74 | 9.3 | 0.86 | 32.2 | 18.9 | 1.51 | 8.1 | 0.82 |
| Other Manufacturing | 39.9 | 21.9 | 2.22 | 11.1 | 0.9 | 18.5 | 14.1 | 1.53 | 10.6 | 0.89 |
| Paper & Allied | 79.2 | 8.5 | 6.74 | 6.6 | 0.75 | 34.4 | 4.9 | 2.93 | 3.8 | 0.49 |
| Plastic | 54.7 | 28.2 | 1.97 | 9.2 | 0.86 | 23.4 | 36.4 | 1.10 | 15.6 | 0.95 |
| Primary Metal | 78.7 | 15.0 | 6.30 | 10.9 | 0.89 | 33.8 | 10.7 | 2.34 | 6.7 | 0.76 |
| Primary Textiles | 55.2 | 41.8 | 3.46 | 23.8 | 0.98 | 23.4 | 29.0 | 1.82 | 20.6 | 0.97 |
| Printing, Publishing & Allied | 57.1 | 40.0 | 3.03 | 19.3 | 0.96 | 35.6 | 34.0 | 1.96 | 17.0 | 0.95 |
| Refined Petroleum & Coal | 1290.6 | 10.0 | 2.52 | 0.2 | –0.07 | 152.5 | 11.1 | 1.39 | 0.9 | -0.01 |
| Rubber | 52.2 | 16.9 | 3.10 | 9.2 | 0.86 | 26.9 | 23.6 | 1.28 | 10.2 | 0.89 |
| Textiles | 43.0 | 41.5 | 1.81 | 15.9 | 0.95 | 18.2 | 26.1 | 0.88 | 11.5 | 0.9 |
| Tobacco | 115.8 | 8.5 | 31.80 | 21.2 | 0.97 | 36.3 | 3.0 | 23.50 | 17.8 | 0.96 |
| Transportation Equipment | 79.1 | 10.1 | 9.11 | 10.6 | 0.89 | 25.6 | 8.6 | 2.68 | 8.2 | 0.83 |
| Wood | 43.5 | 12.3 | 4.70 | 12.1 | 0.91 | 19.1 | 8.4 | 1.73 | 6.9 | 0.77 |
| **Total Manufacturing** | **72.1** | **19.0** | **4.86** | **11.8** | **0.91** | **28.0** | **21.7** | **2.02** | **14.3** | **0.94** |

To overcome this difficulty, we need to compare labour productivity per employed person instead of labour productivity per person-hour paid. Based on Statistics Canada's publication (*Canadian Economic Observer*), of the GDP at factor cost by industry, consistent data for GDP by industry and employment by industry are available, and therefore a sectoral comparison of labour productivity per employed person for the national economy is possible.

It is clear from Table 9 that the Utilities sector had the largest labour productivity level in the Canadian economy, with $176,757 in 1997, followed by Finance, Insurance, and Real Estate with $138,941, and Transportation, Storage and Communication with $60,872. The Manufacturing sector was in fourth place with $56,299. The Other Primary Industries sector, including fishing, trapping, logging, forestry, and mining, had the lowest labour productivity level in the national economy, with only $17,209 in 1997.

The Agriculture sector registered the fastest compound annual growth rate with 3.2% between 1983 and 1997, followed by Transportation, Storage and

**Table 7: Regional Comparison of Labour Productivity in the Manufacturing Sector (shipments per hour worked in 1992 dollars)**

| Industries by 2-Digit SIC Level | Quebec 1983 | Quebec 1990 | Quebec 1997 | Prairies 1983 | Prairies 1990 | Prairies 1997 | Ontario 1983 | Ontario 1990 | Ontario 1997 |
|---|---|---|---|---|---|---|---|---|---|
| Beverage | 145 | 196 | 233 | 140 | 198 | 246 | 207 | 236 | 319 |
| Chemical | 157 | 190 | 231 | 297 | 348 | 443 | 202 | 208 | 208 |
| Clothing | 33 | 43 | 49 | 33 | 35 | 38 | 28 | 35 | 39 |
| Electrical & Electronics | 32 | 42 | 50 | 75 | 125 | 184 | 74 | 93 | 145 |
| Fabricated Metals | 72 | 65 | 74 | 62 | 62 | 62 | 66 | 61 | 64 |
| Furniture & Fixtures | 42 | 44 | 54 | x | x | x | 52 | 43 | 59 |
| Leather & Allied | 36 | 43 | 51 | x | x | x | 42 | 38 | 38 |
| Machinery | 66 | 86 | 102 | 88 | 78 | 94 | 84 | 82 | 100 |
| Non-metallic Minerals | 74 | 73 | 91 | 102 | 88 | 106 | 78 | 78 | 103 |
| Other | x | x | x | 40 | 46 | 58 | 79 | 81 | 102 |
| Paper & Allied | 98 | 104 | 146 | x | x | x | 97 | 104 | 119 |
| Primary Metal | 117 | 133 | 183 | x | x | x | 80 | 100 | 128 |
| Primary Textiles | 67 | 80 | 92 | x | x | x | 63 | 84 | 106 |
| Printing & Publishing | 87 | 85 | 80 | x | x | x | 81 | 90 | 92 |
| Refined Petroleum & Coal | 1256 | 1332 | 1275 | x | x | x | 1138 | 1068 | 1204 |
| Rubber | x | x | x | x | x | x | 70 | 71 | 91 |
| Textiles | 56 | 59 | 75 | 56 | 45 | 41 | 57 | 54 | 65 |
| Food | 159 | 148 | 143 | 196 | 189 | 187 | 144 | 140 | 145 |
| Plastic | 72 | 65 | 77 | x | x | x | 73 | 67 | 76 |
| Tobacco | x | x | x | x | x | x | x | x | x |
| Transportation Equipment | 107 | 120 | 156 | 64 | 74 | 71 | 138 | 163 | 215 |
| Wood | 55 | 70 | 73 | x | x | x | 57 | 58 | 59 |
| **Total Manufacturing** | **87** | **94** | **117** | **125** | **123** | **129** | **100** | **105** | **130** |

Communications with 2.7%, and the Manufacturing sector with 2.5%. It is of note that the Construction, and Other Primary Industries sectors both experienced negative growth of labour productivity in this period, with –1.3 and –0.8 respectively.

The substantial decline of labour productivity growth rate for the Construction sector is likely due to the long recession experienced by the sector since 1990. The negative labour productivity growth rate for the Other Primary Industries sector is mainly attributed to relatively low commodity prices in the international markets.

## Table 7 (con't): Regional Comparison of Labour Productivity in the Manufacturing Sector (shipments per hour worked in 1992 dollars)

| Industries by 2-Digit SIC Level | British Columbia | | | Atlantic Canada | | | Canada | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1983 | 1990 | 1997 | 1983 | 1990 | 1997 | 1983 | 1990 | 1997 |
| Beverage | 145 | 180 | 238 | x | x | x | 167 | 207 | 266 |
| Chemical | 215 | 188 | 211 | 163 | 148 | 152 | 197 | 216 | 242 |
| Clothing | 28 | 30 | 33 | x | x | x | 31 | 39 | 44 |
| Electrical & Electronics | 71 | 72 | 119 | 46 | 80 | 69 | 73 | 94 | 157 |
| Fabricated Metals | 75 | 73 | 72 | 57 | 64 | 58 | 68 | 63 | 66 |
| Furniture & Fixtures | 50 | 50 | 50 | x | x | x | 48 | 44 | 55 |
| Leather & Allied | x | x | x | x | x | x | 40 | 42 | 46 |
| Machinery | 77 | 77 | 83 | 52 | 57 | 56 | 81 | 81 | 97 |
| Non-metallic Minerals | 92 | 102 | 102 | x | x | x | 82 | 79 | 99 |
| Other | 41 | 37 | 54 | x | x | x | 57 | 53 | 65 |
| Paper & Allied | 138 | 149 | 160 | x | x | x | 104 | 114 | 140 |
| Primary Metal | 75 | 73 | 108 | x | x | x | 89 | 110 | 146 |
| Primary Textiles | x | x | x | x | x | x | 65 | 83 | 100 |
| Printing & Publishing | x | x | x | 68 | 63 | 52 | 89 | 85 | 81 |
| Refined Petroleum & Coal | 1237 | 1150 | 1620 | x | x | x | 1145 | 1149 | 1393 |
| Rubber | x | x | x | x | x | x | 68 | 71 | 93 |
| Textiles | 42 | 41 | 43 | x | x | x | 56 | 55 | 66 |
| Food | 76 | 74 | 74 | x | x | x | 138 | 135 | 140 |
| Plastic | 81 | 67 | 64 | x | x | x | 74 | 67 | 75 |
| Tobacco | x | x | x | x | x | x | 292 | 440 | 498 |
| Transportation Equipment | 61 | 82 | 82 | x | x | x | 125 | 148 | 191 |
| Wood | 85 | 101 | 113 | 47 | 57 | 58 | 68 | 77 | 80 |
| **Total Manufacturing** | **103** | **104** | **115** | **82** | **91** | **103** | **98** | **103** | **124** |

**Table 8: Regional Comparison of Real Labour Productivity Growth Rates in the Manufacturing Sector, 1983 to 1997**

| Industries by 2-Digit SIC Level | Quebec (%) | Prairies (%) | Ontario (%) | British Columbia (%) | Atlantic Canada (%) | Canada (%) |
|---|---|---|---|---|---|---|
| Beverage | 3.46 | 4.11 | 3.15 | 3.61 | x | 3.40 |
| Chemical | 2.80 | 2.91 | 0.20 | –0.15 | –0.48 | 1.50 |
| Clothing | 2.86 | 1.04 | 2.40 | 1.20 | x | 2.40 |
| Electrical & Electronics | 3.20 | 6.61 | 4.97 | 3.80 | 2.92 | 5.70 |
| Fabricated Metals | 0.20 | 0.00 | –0.22 | –0.25 | 0.15 | –0.10 |
| Furniture & Fixtures | 1.82 | x | 0.88 | 0.02 | x | 1.00 |
| Leather & Allied Products | 2.51 | x | –0.69 | x | x | 1.00 |
| Machinery | 3.09 | 0.47 | 1.21 | 0.54 | 0.54 | 1.30 |
| Non-metallic Minerals | 1.48 | 0.3 | 2.03 | 0.77 | x | 1.30 |
| Other | x | 2.63 | 1.80 | 2.02 | x | 1.00 |
| Paper & Allied Products | 2.92 | x | 1.51 | 1.08 | x | 2.20 |
| Primary Metal | 3.23 | x | 3.37 | 2.69 | x | 3.60 |
| Primary Textiles | 2.30 | x | 3.81 | x | x | 3.20 |
| Printing & Publishing | –0.50 | x | 0.92 | x | –1.91 | –0.60 |
| Refined Petroleum & Coal | 0.11 | x | 0.41 | 1.95 | x | 1.40 |
| Rubber | x | x | 1.84 | x | x | 2.30 |
| Textiles | 2.15 | –2.15 | 0.88 | 0.28 | x | 1.10 |
| Food | –0.78 | –0.35 | 0.03 | –0.21 | x | 0.10 |
| Plastic | 0.45 | x | 0.33 | –1.68 | x | 0.10 |
| Tobacco | x | x | x | x | x | 3.90 |
| Transportation Equipment | 2.74 | 0.75 | 3.23 | 2.23 | x | 3.10 |
| Wood | 2.07 | x | 0.21 | 2.06 | 1.50 | 1.20 |
| **Total Manufacturing** | **2.14** | **0.22** | **1.88** | **0.74** | **1.66** | **1.70** |

Table 9: Comparison of Labour Productivity per Employed Persons Within the National Economy (in constant 1992 dollars of GDP at factor cost)

| Industrial Sector | Year 1983 | Year 1990 | Year 1997 | Average Annual Growth Rate 1983–1997 (%) |
|---|---|---|---|---|
| Agriculture | 18,638 | 25,812 | 28,993 | 3.21 |
| Other Primary Industries | 19,248 | 19,440 | 17,209 | –0.80 |
| Construction | 62,800 | 52,795 | 52,292 | –1.30 |
| Transportation, Storage & Communication | 41,802 | 52,411 | 60,872 | 2.72 |
| Finance, Insurance & Real Estate | 116,698 | 115,984 | 138,941 | 1.25 |
| Trade | 25,085 | 28,421 | 33,845 | 2.16 |
| Utilities | 156,870 | 154,901 | 176,757 | 0.86 |
| Manufacturing | 40,101 | 48,727 | 56,299 | 2.45 |
| **Total Economy** | **43,292** | **46,259** | **50,090** | **1.05** |

Source: Statistics Canada. *Canadian Economic Observer: Historical Statistical Supplement 1998/99*.

## International Comparison of Labour Productivity

It is also of great interest to compare Canadian labour productivity with that of other developed economies in the world, particularly with the G-7. Based on data available, this section will compare Canadian labour productivity in the manufacturing sector with the United States, France, Italy, and Japan.

### Labour Productivity in the Manufacturing Sector – Canada vs United States

In this study, we used real value of shipment per person-hour worked to represent Canada's labour productivity level; however, the US Bureau of Labour Statistics published the corresponding US labour productivity of the manufacturing sector in index form, instead of level form. Based on this price index, we computed compound annual growth rates for the US manufacturing sector and its individual industrial groups. Also, the published US labour productivity price index was for 1983 to 1996. For comparison purposes, we recalculated Canada's manufacturing labour productivity growth rates for the same period.

A comparison of labour productivity growth rates for both Canada and the US manufacturing sector and individual industrial groups is presented in Table 10. The results indicate that the US labour productivity in the overall manufacturing sector grew by 3.1%, which is much greater than 1.6% for Canada between 1983 and 1996. Of the 18 comparable industrial groups, the United States led in 11 industries – Food, Rubber and Plastic Products, Leather and Allied Products, Furniture and Fixtures, Printing, Publishing and Allied, Fabricated Metal Products, Machinery, Electrical and Electronic Products, Refined Petroleum and Coal Products, Chemical and Chemical Products, and Other Manufacturing. Canada led in seven industries – Tobacco Products, Primary Textile, Clothing, Wood, Paper and Allied Products, Primary Metal, and Transportation Equipment.

The remarkable growth of the US labour productivity for the period 1983 to1996 is mainly contributed by two industrial groups: Electrical and Electronic Products, and Machinery, which happen to be high-tech industries. It is estimated that these two industrial groups alone might have contributed about 90% of the labour productivity growth in the manufacturing sector in the United States.

Investment and advanced technology use appear to be the major reasons contributing to the remarkable growth of labour productivity in the US Electrical and Electronic Products, and Machinery industries. The United States has, either by accident or design, invested

**Table 10: US and Canadian Labour Productivity for Comparable Groups (1992=100: $/hour)**

| Industries by 2-Digit SIC Level | US Indexes 1983 | US Indexes 1996 | US Average Annual Growth Rate 1983–1996 (%) | CDN Average Annual Growth Rate 1983–1996 (%) |
|---|---|---|---|---|
| Food | 88 | 101 | 1.02 | 0.00 |
| Beverage | x | x | x | 3.10 |
| Tobacco | 81 | 121 | 3.09 | 3.90 |
| Rubber & Plastic | 75 | 111 | 3.13 | 1.60 |
| Leather & Allied | 83 | 101 | 1.55 | 0.50 |
| Primary Textiles/Textile Mill | 83 | 118 | 2.77 | 2.80 |
| Textile Products | x | x | x | 0.10 |
| Clothing/Apparel | 85 | 119 | 2.61 | 2.70 |
| Wood/Lumber & Wood | 87 | 95 | 0.76 | 1.20 |
| Furniture & Fixtures | 87 | 110 | 1.85 | 0.80 |
| Paper & Allied | 89 | 106 | 1.36 | 2.30 |
| Printing & Publishing | 99 | 99 | 0.03 | –0.69 |
| Primary Metal | 79 | 111 | 2.65 | 3.40 |
| Fabricated Metal | 89 | 107 | 1.46 | –0.20 |
| Machinery | 62 | 150 | 7.04 | 1.20 |
| Transportation Equipment | 81 | 112 | 2.53 | 3.00 |
| Electrical & Electronics | 56 | 170 | 8.99 | 5.80 |
| Non-metallic Mineral | x | x | x | 1.00 |
| Refined Petroleum & Coal | 72 | 118 | 3.88 | 1.20 |
| Chemical | 87 | 111 | 1.91 | 1.10 |
| Other Manufacturing | 85 | 111 | 2.13 | 0.90 |
| **Total Manufacturing** | **x** | **x** | **3.06** | **1.63** |

Sources: Statistics Canada and US Bureau of Labour Statistics.

a considerable amount of money in these two high-tech industries during the past decade. A great portion of these investment funds actually came from foreign direct investment, which is normally more productive because it often finances the adoption of more advanced technology.

Canada and US labour productivity can also be assessed on a comparable basis. To do so, we needed consistent data from the same source. Based on the OECD National Accounts, we obtained consistent statistical data on manufacturing output, person-hours, and a price index of purchasing power parity (PPP). These data are presented in Table 11.

Canada's labour productivity has been converted into US dollar measurement using the PPP price index, which allows direct comparison to US counterparts. Table 11 also reports Canada and the US labour productivity measured in common currency and their growth rates for the period 1983 to 1996. Labour productivity growth rates, measured in the same purchasing power, are still the common currency measure. US labour

**Table 11: Comparison of Canadian and American Manufacturing Labour Productivity – Based on Output per Hour (1992 prices)**

| | Canada | | | | | United States | | | Canadian |
|---|---|---|---|---|---|---|---|---|---|
| Year | Output (billions) $ | Person-hours (billions) | Productivity Level ($/person-hour) | PPP | PPP Adjusted productivity ($/person-hour) | Output (billions) $ | Person-hours (billions) | Productivity Level ($/person-hour) | Productivity Levels Relative to the US=100 |
| 1983 | 80 | 3.9 | 20.5 | 1.31 | 15.6 | 846 | 35.3 | 24.0 | 65.3% |
| 1984 | 89 | 4.1 | 21.7 | 1.30 | 16.7 | 913 | 37.5 | 24.3 | 68.6% |
| 1985 | 94 | 4.1 | 22.9 | 1.28 | 17.9 | 937 | 37.2 | 25.2 | 71.1% |
| 1986 | 95 | 4.2 | 22.6 | 1.29 | 17.5 | 945 | 36.5 | 25.9 | 67.7% |
| 1987 | 99 | 4.3 | 23.0 | 1.31 | 17.6 | 1052 | 36.8 | 28.6 | 61.5% |
| 1988 | 105 | 4.4 | 23.9 | 1.31 | 18.2 | 1113 | 37.8 | 29.4 | 61.9% |
| 1989 | 107 | 4.5 | 23.8 | 1.32 | 18.0 | 1107 | 37.8 | 29.3 | 61.5% |
| 1990 | 103 | 4.2 | 24.5 | 1.30 | 18.9 | 1097 | 37.0 | 29.6 | 63.6% |
| 1991 | 95 | 3.9 | 24.4 | 1.29 | 18.9 | 1059 | 35.6 | 29.7 | 63.5% |
| 1992 | 96 | 3.7 | 25.9 | 1.28 | 20.3 | 1073 | 35.2 | 30.5 | 66.5% |
| 1993 | 102 | 3.8 | 26.8 | 1.26 | 21.3 | 1111 | 35.6 | 31.2 | 68.3% |
| 1994 | 108 | 3.9 | 27.7 | 1.25 | 22.2 | 1210 | 36.3 | 33.3 | 66.5% |
| 1995 | 114 | 4.1 | 27.8 | 1.19 | 23.4 | 1325 | 36.4 | 36.4 | 64.2% |
| 1996 | 115 | 4.1 | 28.0 | 1.19 | 23.6 | 1453 | 36.4 | 39.9 | 59.0% |
| Growth Rate 1983–1996 | | | 2.5% | | 3.2% | | | 4.0% | |
| Growth Rate 1990–1996 | | | 2.2% | | 3.8% | | | 5.1% | |

Source: OECD. *National Accounts of OECD Countries*, 1997, 1998, 1999.

productivity grew much faster than that of Canada using both measurements.

For the period 1983 to 1996, the real growth rate of US labour productivity, measured in output per hour, was 4%, which was higher than 3.2% for Canada. If we look only at the 1990s, the US growth rate was remarkably high at 5.1%, compared with 3.8% for Canada. In terms of level, Canada's labour productivity, measured in output per hour in US purchasing power, was equal to 65% of the United States in 1983, and then gradually decreased to only 59% by 1996.

In a recent conference in Ottawa on Canada-US manufacturing productivity, the empirical results confirmed that the Canada-US manufacturing labour productivity gap is real and significant. The major reasons underlying the gap likely come from several sources: measurement problems (due to different depreciation rates, capital stock, price indices used), cyclical movement (recession in Canada in the early 1990s), institutional factors (taxation, monetary policy, social policy), industrial structure (scale of economy, trade increases), and the use of advanced technologies (increased investment, more foreign direct investment).

If labour productivity is measured in output per person in US purchasing power, the results are still the same as measured in output per hour. Table 12 indicates that the US labour productivity based on output per person grew at an average rate of 4.1%, compared with 3.1% for Canada between 1983 and 1996. In the 1990s, the US labour productivity still outperformed that of Canada, growing at an average rate of 5.2% compared to 3.6% for Canada.

**Table 12: Comparison of Canadian and American Manufacturing Labour Productivity, Based on Output per Person (1992 prices)**

| | Canada | | | | | United States | | | Canadian Productivity Levels Relative to the US=100 |
|---|---|---|---|---|---|---|---|---|---|
| Year | Output (billions) $ | Persons (millions) | Productivity Level (thousands) | PPP | PPP Adjusted productivity (thousands) | Output (billions) $ | Persons (millions) | Productivity Level (thousands) | |
| 1983 | 80 | 1.96 | 40.8 | 1.31 | 31.2 | 846 | 18.34 | 46.1 | 67.5% |
| 1984 | 89 | 2.05 | 43.4 | 1.30 | 33.4 | 913 | 19.29 | 47.3 | 70.6% |
| 1985 | 94 | 2.06 | 45.6 | 1.28 | 35.7 | 937 | 19.14 | 49.0 | 72.8% |
| 1986 | 95 | 2.10 | 45.2 | 1.29 | 35.1 | 945 | 18.88 | 50.1 | 70.1% |
| 1987 | 99 | 2.13 | 46.5 | 1.31 | 35.5 | 1052 | 18.96 | 55.5 | 63.9% |
| 1988 | 105 | 2.21 | 47.5 | 1.31 | 36.3 | 1113 | 19.34 | 57.6 | 63.0% |
| 1989 | 107 | 2.24 | 47.8 | 1.32 | 36.2 | 1107 | 19.40 | 57.1 | 63.4% |
| 1990 | 103 | 2.11 | 48.8 | 1.30 | 37.6 | 1097 | 19.05 | 57.6 | 65.2% |
| 1991 | 95 | 1.96 | 48.5 | 1.29 | 37.6 | 1059 | 18.43 | 57.5 | 65.4% |
| 1992 | 96 | 1.88 | 51.1 | 1.28 | 39.9 | 1073 | 18.07 | 59.4 | 67.2% |
| 1993 | 102 | 1.89 | 54.0 | 1.26 | 42.8 | 1111 | 18.11 | 61.3 | 69.8% |
| 1994 | 108 | 1.95 | 55.4 | 1.25 | 44.3 | 1210 | 18.45 | 65.6 | 67.6% |
| 1995 | 114 | 2.06 | 55.3 | 1.19 | 46.5 | 1325 | 18.61 | 71.2 | 65.3% |
| 1996 | 115 | 2.08 | 55.3 | 1.19 | 46.5 | 1453 | 18.58 | 78.2 | 59.4% |
| Growth Rate 1983–96 | | | | | 3.12% | | | 4.14% | |
| Growth Rate 1990–96 | | | | | 3.61% | | | 5.23% | |

Source: OECD. *National Accounts of OECD Countries*, 1997, 1998, 1999.

**Table 13: Canadian and French Manufacturing Labour Productivity, Output per Person in US Dollars**

| | Canada - 1992 Prices | | | | | | France - 1980 Prices | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Output (billions) $ | Persons (millions) | Productivity Level (thousands) | PPP | PPP Adjusted Productivity (thousands) | Annual Growth Rates | Output (billion) F.F | Persons (millions) | PPP | PPP Adjusted productivity (thousands) | Annual Growth Rates |
| 1983 | 80 | 1.96 | 40.8 | 1.31 | 31.2 | | 683.5 | 5.05 | 6.32 | 21.4 | |
| 1984 | 89 | 2.05 | 43.4 | 1.30 | 33.4 | 7.2% | 671.0 | 4.90 | 6.49 | 21.1 | -1.5% |
| 1985 | 94 | 2.06 | 45.6 | 1.28 | 35.7 | 6.7% | 668.4 | 4.77 | 6.64 | 21.1 | 0.0% |
| 1986 | 95 | 2.10 | 45.2 | 1.29 | 35.1 | -1.6% | 667.3 | 4.69 | 6.82 | 20.9 | -1.2% |
| 1987 | 99 | 2.13 | 46.5 | 1.31 | 35.5 | 1.2% | 661.1 | 4.57 | 6.80 | 21.3 | 2.0% |
| 1988 | 105 | 2.21 | 47.5 | 1.31 | 36.3 | 2.2% | 700.5 | 4.50 | 6.75 | 23.1 | 8.4% |
| 1989 | 107 | 2.24 | 47.8 | 1.32 | 36.2 | -0.2% | 736.6 | 4.53 | 6.69 | 24.3 | 5.4% |
| 1990 | 103 | 2.11 | 48.8 | 1.30 | 37.6 | 3.8% | 750.4 | 4.56 | 6.61 | 24.9 | 2.4% |
| 1991 | 95 | 1.96 | 48.5 | 1.29 | 37.6 | 0.1% | 736.2 | 4.48 | 6.51 | 25.2 | 1.4% |
| 1992 | 96 | 1.88 | 51.1 | 1.28 | 39.9 | 6.2% | 722.3 | 4.34 | 6.42 | 25.9 | 2.7% |
| 1993 | 102 | 1.89 | 54.0 | 1.26 | 42.8 | 7.4% | 699.8 | 4.13 | 6.57 | 25.8 | -0.5% |
| 1994 | 108 | 1.95 | 55.4 | 1.25 | 44.3 | 3.4% | 732.1 | 4.02 | 6.62 | 27.5 | 6.7% |
| 1995 | 114 | 2.06 | 55.3 | 1.19 | 46.5 | 5.0% | 762.1 | 4.01 | 6.49 | 29.3 | 6.5% |
| 1996 | 115 | 2.08 | 55.3 | 1.19 | 46.5 | -0.1% | 765.2 | 3.96 | 6.57 | 29.4 | 0.4% |
| Growth Rate 1983–96 | | | | | 3.12% | | | | | 2.50% | |
| Growth Rate 1990–96 | | | | | 3.61% | | | | | 2.82% | |

Source: OECD. *National Accounts of OECD Countries*, 1997, 1998, 1999.

## Labour Productivity in the Manufacturing Sector – Canada vs France

Using the OECD data source, we compared Canada's labour productivity adjusted by PPP with that of France. As data for France were originally based on 1980 prices, it is improper to compare French labour productivity in level form with that of Canada.

Table 13 reports labour productivity per person adjusted by the respective PPP for Canada and France. The results indicate that Canada's labour productivity in the manufacturing sector grew faster; 3.1% for Canada for the period 1983 to 1996, compared with 2.5% for France. In the 1990s, it was 3.6% for Canada, compared with 2.8% for France.

**Table 14: Canadian and Italian Manufacturing Labour Productivity, Output per Person in US Dollars**

| | Canada - 1992 Prices | | | | | | Italy - 1980 Prices | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Output (billions) $ | Persons (millions) | Productivity Level (thousands) | PPP | PPP Adjusted Productivity (thousands) | Annual Growth Rates | Output (billion) lira | Persons (millions) | PPP | PPP Adjusted Productivity (thousands) | Annual Growth Rates |
| 1983 | 80 | 1.96 | 40.8 | 1.31 | 31.2 | | 225943 | 5.39 | 1084 | 38.7 | |
| 1984 | 89 | 2.05 | 43.4 | 1.30 | 33.4 | 7.2% | 236563 | 5.14 | 1156 | 39.7 | 2.5% |
| 1985 | 94 | 2.06 | 45.6 | 1.28 | 35.7 | 6.7% | 243259 | 5.07 | 1217 | 39.4 | -0.6% |
| 1986 | 95 | 2.10 | 45.2 | 1.29 | 35.1 | -1.6% | 249694 | 5.04 | 1281 | 38.7 | -1.9% |
| 1987 | 99 | 2.13 | 46.5 | 1.31 | 35.5 | 1.2% | 259719 | 4.99 | 1316 | 39.6 | 2.3% |
| 1988 | 105 | 2.21 | 47.5 | 1.31 | 36.3 | 2.2% | 277749 | 5.08 | 1353 | 40.4 | 2.2% |
| 1989 | 107 | 2.24 | 47.8 | 1.32 | 36.2 | -0.2% | 288519 | 5.12 | 1378 | 40.9 | 1.2% |
| 1990 | 103 | 2.11 | 48.8 | 1.30 | 37.6 | 3.8% | 293622 | 5.14 | 1421 | 40.2 | -1.7% |
| 1991 | 95 | 1.96 | 48.5 | 1.29 | 37.6 | 0.1% | 291594 | 5.04 | 1463 | 39.6 | -1.6% |
| 1992 | 96 | 1.88 | 51.1 | 1.28 | 39.9 | 6.2% | 291651 | 4.85 | 1459 | 41.2 | 4.2% |
| 1993 | 102 | 1.89 | 54.0 | 1.26 | 42.8 | 7.4% | 282497 | 4.61 | 1534 | 40.0 | -3.1% |
| 1994 | 108 | 1.95 | 55.4 | 1.25 | 44.3 | 3.4% | 297973 | 4.59 | 1533 | 42.3 | 6.0% |
| 1995 | 114 | 2.06 | 55.3 | 1.19 | 46.5 | 5.0% | 314112 | 4.57 | 1556 | 44.2 | 4.3% |
| 1996 | 115 | 2.08 | 55.3 | 1.19 | 46.5 | -0.1% | 310315 | 4.53 | 1583 | 43.3 | -2.0% |
| Growth Rate 1983–96 | | | | | 3.12% | | | | | 0.87% | |
| Growth Rate 1990–96 | | | | | 3.61% | | | | | 1.24% | |

Source: OECD. *National Accounts of OECD Countries*, 1997, 1998, 1999.

## Labour Productivity in the Manufacturing Sector – Canada vs Italy

Regarding labour productivity growth in the manufacturing sector, Italy was probably the least performing among G-7 countries. Using OECD data, labour productivity per person adjusted by PPP for Canada and Italy are presented in Table 14. The results indicate that Canada's labour productivity growth was much greater than that of Italy; 3.1% for Canada, compared with 0.9% for Italy for the period 1983 to 1996. Much labour unrest in Italy was probably contributing to its relatively low growth of labour productivity.

Italy's labour productivity growth in the 1990s was much improved; however, it was still much less than that in Canada. The results in Table 14 indicate that the labour productivity growth rate was 1.2% for Italy, compared with 3.6% for Canada between 1990 and 1996.

**Table 15: Canadian and Japanese Manufacturing Labour Productivity, Output per Person in US Dollars**

| | Canada - 1992 Prices | | | | | | Japan-1990 Prices | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Output (billions) $ | Persons (millions) | Productivity Level (thousands) | PPP | PPP Adjusted Productivity (thousands) | Annual Growth Rates | Output (billions) Yen | Persons (millions) | PPP | PPP Adjusted Productivity (thousands) | Annual Growth Rates |
| 1983 | 80 | 1.96 | 40.8 | 1.31 | 31.2 | | 83145 | 14.36 | 226 | 25.6 | |
| 1984 | 89 | 2.05 | 43.4 | 1.30 | 33.4 | 7.2% | 88588 | 14.65 | 221 | 27.4 | 6.8% |
| 1985 | 94 | 2.06 | 45.6 | 1.28 | 35.7 | 6.7% | 95718 | 14.78 | 218 | 29.7 | 8.6% |
| 1986 | 95 | 2.10 | 45.2 | 1.29 | 35.1 | -1.6% | 94230 | 14.70 | 217 | 29.5 | -0.6% |
| 1987 | 99 | 2.13 | 46.5 | 1.31 | 35.5 | 1.2% | 98613 | 14.54 | 210 | 32.3 | 9.3% |
| 1988 | 105 | 2.21 | 47.5 | 1.31 | 36.3 | 2.2% | 106506 | 14.85 | 204 | 35.2 | 8.9% |
| 1989 | 107 | 2.24 | 47.8 | 1.32 | 36.2 | -0.2% | 113490 | 15.17 | 199 | 37.6 | 6.9% |
| 1990 | 103 | 2.11 | 48.8 | 1.30 | 37.6 | 3.8% | 121219 | 15.42 | 195 | 40.3 | 7.2% |
| 1991 | 95 | 1.96 | 48.5 | 1.29 | 37.6 | 0.1% | 127598 | 15.91 | 193 | 41.5 | 3.1% |
| 1992 | 96 | 1.88 | 51.1 | 1.28 | 39.9 | 6.2% | 125822 | 16.08 | 188 | 41.6 | 0.2% |
| 1993 | 102 | 1.89 | 54.0 | 1.26 | 42.8 | 7.4% | 120841 | 15.74 | 184 | 41.7 | 0.2% |
| 1994 | 108 | 1.95 | 55.4 | 1.25 | 44.3 | 3.4% | 119986 | 15.42 | 181 | 43.0 | 3.0% |
| 1995 | 114 | 2.06 | 55.3 | 1.19 | 46.5 | 5.0% | 126554 | 15.04 | 169 | 49.8 | 15.8% |
| 1996 | 115 | 2.08 | 55.3 | 1.19 | 46.5 | -0.1% | 129840 | 14.95 | 166 | 52.3 | 5.1% |
| Growth Rate 1983–96 | | | | | 3.12% | | | | | 5.65% | |
| Growth Rate 1990–96 | | | | | 3.61% | | | | | 4.44% | |

Source: OECD. *National Accounts of OECD Countries*, 1997, 1998, 1999.

### Labour Productivity in the Manufacturing Sector – Canada vs Japan

Japan was probably the best performer among the G-7 in manufacturing labour productivity growth between 1983 and 1996. Based on OECD data, we computed labour productivity per person adjusted by PPP for Canada and Japan. The information is summarized in Table 15. For the whole period covered by this study, Japan registered a remarkable 5.7% growth of labour productivity per person, which is substantially higher than 3.1% for Canada.

However, Japan's labour productivity per person grew much more slowly in the 1990s, at 4.4%, but this is still higher than Canada's at 3.6%.

# Employment Performance in the Manufacturing Sector

## Manufacturing Employment Relative to National Employment

The manufacturing sector has a significant presence in national employment, employing 1.67 million persons in 1983. This accounted for 15.0% of total employment. Manufacturing's employment share gradually increased to 15.2% by 1988. However, when the Free Trade Agreement (FTA) went into effect in 1989, the manufacturing sector's employment share started to decline due to industrial specialization and rationalization. Manufacturing employment share continued to decline and reached its lowest point, 12.6%, by 1994, which coincided with the implementation of the North American Free Trade Agreement (NAFTA). Since then, however, the employment share for the manufacturing sector has gradually increased and reached 13.2% in 1997. Figure 6 presents manufacturing's share of employment in the economy.

Figure 7 compares employment growth rates between the manufacturing and non-manufacturing sectors. The results show that employment in the manufacturing sector is more sensitive than the non-manufacturing sector in response to economic boom and bust. Over the period 1983 to 1997, the compound annual growth rate for total national employment was 1.6% while that of manufacturing was only 0.7%, significantly below the non-manufacturing industries' rate of 1.8%.

A closer examination of the data in Table 16 reveals that the share employed in manufacturing had remained stable up until 1989 at about 15% after which it experienced a persistent decline until 1993. In the worst year, 1991, manufacturing employment had fallen 7% from 1990, the largest annual decline during this period. In contrast, non-manufacturing employment growth faired much better during the 1989 to 1993 period with employment levels declining between only 1990 to 1991, and 1991 to 1992. The largest contraction for non-manufacturers also occurred in 1991 but was only –1%. As a result of the relative gap in employment growth trends, manufacturing industries' share of employment reached a low of 12.6% in 1993 and remained there through 1994.

Since 1993, manufacturing employment has reversed its downward trend and has actually performed relatively better than non-manufacturing employment growth. Between 1993 and 1997, national employment levels grew at an annual rate of 1.7% with manufacturing employment growing at 2.9%, outpacing non-manufacturing which grew at only an average annual rate of 1.6%. This relative gap had the effect of increasing the share of employment in manufacturing to 13.2%. Although this marks an improvement, it is still a relatively weak recovery given that in the previous four-year period, the average annual employment growth rate was –4.4% for manufacturing employment. By 1997, there were more than 128,000 fewer people employed in manufacturing than in 1989 when the sector employed more than 1,969,000. It therefore appears that if not for the even poorer growth of non-manufacturing employment during the 1990s, the apparent recovery in manufacturing employment would have been even weaker.

**Figure 6: Manufacturing's Share of Employment in the Economy**

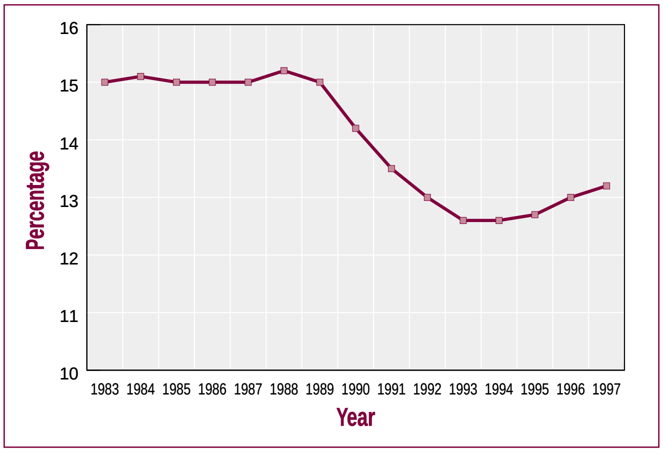



**Figure 7: Comparison of Manufacturing vs Non-manufacturing Employment Growth**

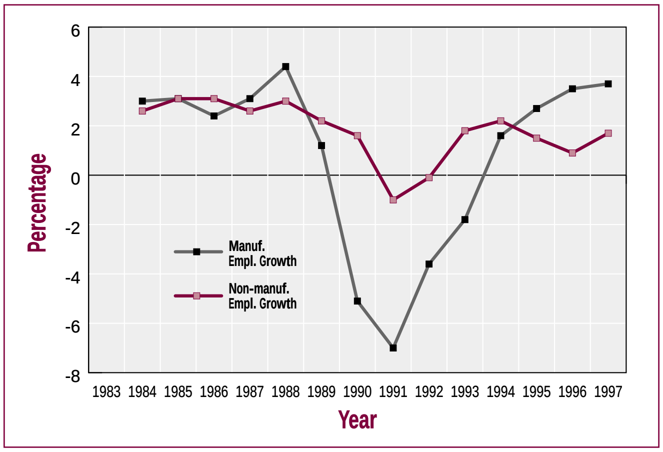


**Table 16: Comparisons of National Employment and Manufacturing Employment**

| Year | National Employment | Manufacturing Employment | Manufacturing Employment Growth (%) | Manufacturing's Share of Employment (%) | Non-manuf. Employment | Non-manuf. Employment Growth (%) |
|---|---|---|---|---|---|---|
| 1983 | 11 106 000 | 1 671 140 | – | 15.0 | 9 434 860 | – |
| 1984 | 11 402 000 | 1 722 045 | 3.0 | 15.1 | 9 679 955 | 2.6 |
| 1985 | 11 742 000 | 1 766 763 | 2.6 | 15.0 | 9 975 237 | 3.1 |
| 1986 | 12 095 000 | 1 808 716 | 2.4 | 15.0 | 10 286 284 | 3.1 |
| 1987 | 12 422 000 | 1 864 545 | 3.1 | 15.0 | 10 557 455 | 2.6 |
| 1988 | 12 819 000 | 1 946 702 | 4.4 | 15.2 | 10 872 298 | 3.0 |
| 1989 | 13 086 000 | 1 969 325 | 1.2 | 15.0 | 11 116 675 | 2.2 |
| 1990 | 13 165 000 | 1 868 983 | –5.1 | 14.2 | 11 296 017 | 1.6 |
| 1991 | 12 916 000 | 1 737 606 | –7.0 | 13.5 | 11 178 394 | –1.0 |
| 1992 | 12 842 000 | 1 674 444 | –3.6 | 13.0 | 11 167 556 | –0.1 |
| 1993 | 13 015 000 | 1 644 260 | –1.8 | 12.6 | 11 370 740 | 1.8 |
| 1994 | 13 292 000 | 1 670 286 | 1.6 | 12.6 | 11 621 714 | 2.2 |
| 1995 | 13 506 000 | 1 715 160 | 2.7 | 12.7 | 11 790 840 | 1.5 |
| 1996 | 13 676 000 | 1 775 738 | 3.5 | 13.0 | 11 900 262 | 0.9 |
| 1997 | 13 941 000 | 1 840 923 | 3.7 | 13.2 | 12 100 077 | 1.7 |
| 1998 | 14 326 000 | – | – | – | – | – |

Source: Statistics Canada.

### Inter-Industry Employment Distribution Trends

Although manufacturing employment levels grew at an average annual rate of only 0.7% from 1983 to 1997, there were significant differences in the shares of manufacturing employment among the 22 industrial groups. Table 17 indicates that among 22 industrial groups, 12 had lower employment levels in 1997 than in 1983, with seven of these declining at an average annual rate of over 1%. Of the 10 that experienced employment growth, eight had expanded by more than an average annual rate of 1%, less than the total manufacturing average.

The greatest negative average annual growth rates were experienced by Leather and Allied Products at –5.3%, followed by Tobacco Products at –4.6%. An interesting observation is that of the nine industrial groups that experienced labour productivity growth above the manufacturing average, seven were industries that reduced employment levels from 1983 to 1997.

With respect to the 10 groups characterized by expanding employment, the Plastic Products group increased employment by an average rate of 5.34% per year, compared to Food at 0.36%. Only Rubber Products, and Transportation Equipment experienced employment growth together with above average labour productivity growth. Of these two, Transportation Equipment is the most important, accounting for 13.4% of manufacturing employment in 1997 with a labour productivity growth rate estimated at an average annual rate of 3.1% in contrast with 1.7% for total manufacturing. Rubber Products employed only 1.5% of the total manufacturing workforce with a productivity growth rate of 2.3%.

As a result of these growth rates, Other Manufacturing, Furniture and Fixtures, Printing, Publishing and Allied,

**Table 17: Comparison of Manufacturing Industries' Employment Levels**

| Industries by 2-Digit SIC Level | Year 1983 | 1990 | 1997 | Average Annual Growth Rate 1983–1997 (%) | Average Annual Labour Productivity Growth (%) |
|---|---|---|---|---|---|
| Leather & Allied | 23,674 | 16,709 | 11,035 | –5.31 | 1.00 |
| Tobacco | 8,110 | 4,928 | 4,218 | –4.56 | 3.90 |
| Refined Petroleum & Coal | 18,917 | 15,868 | 12,790 | –2.76 | 1.40 |
| Primary Textiles | 29,626 | 20,762 | 20,247 | –2.68 | 3.20 |
| Beverage | 31,327 | 23,859 | 23,879 | –1.92 | 3.40 |
| Clothing | 109,816 | 103,431 | 83,957 | –1.90 | 2.40 |
| Primary Metal | 105,352 | 96,667 | 89,305 | –1.17 | 3.60 |
| Paper & Allied | 114,308 | 115,176 | 103,446 | –0.71 | 2.20 |
| Textiles | 31,164 | 35,278 | 28,324 | –0.68 | 1.10 |
| Non-metallic Mineral | 47,449 | 54,605 | 45,635 | –0.28 | 1.30 |
| Electrical & Electronics | 127,922 | 141,418 | 125,133 | –0.16 | 5.70 |
| Chemical | 87,824 | 94,888 | 86,009 | –0.15 | 1.50 |
| Food | 186,687 | 197,845 | 196,205 | 0.36 | 0.10 |
| Rubber | 25,142 | 24,826 | 27,080 | 0.53 | 2.30 |
| Total Manufacturing | 1,671,140 | 1,868,983 | 1,840,923 | 0.69 | 1.70 |
| Other Manufacturing | 64,046 | 75,437 | 76,177 | 1.25 | 1.00 |
| Printing & Publishing | 110,159 | 141,970 | 134,248 | 1.42 | –0.60 |
| Wood | 101,965 | 115,490 | 130,644 | 1.79 | 1.20 |
| Furniture & Fixtures | 43,694 | 59,110 | 58,353 | 2.09 | 1.00 |
| Fabricated Metal | 129,393 | 166,822 | 173,422 | 2.11 | –0.10 |
| Transportation Equipment | 173,360 | 226,712 | 245,825 | 2.53 | 3.10 |
| Machinery | 69,557 | 85,300 | 99,439 | 2.59 | 1.30 |
| Plastic | 31,648 | 51,882 | 65,552 | 5.34 | 0.10 |

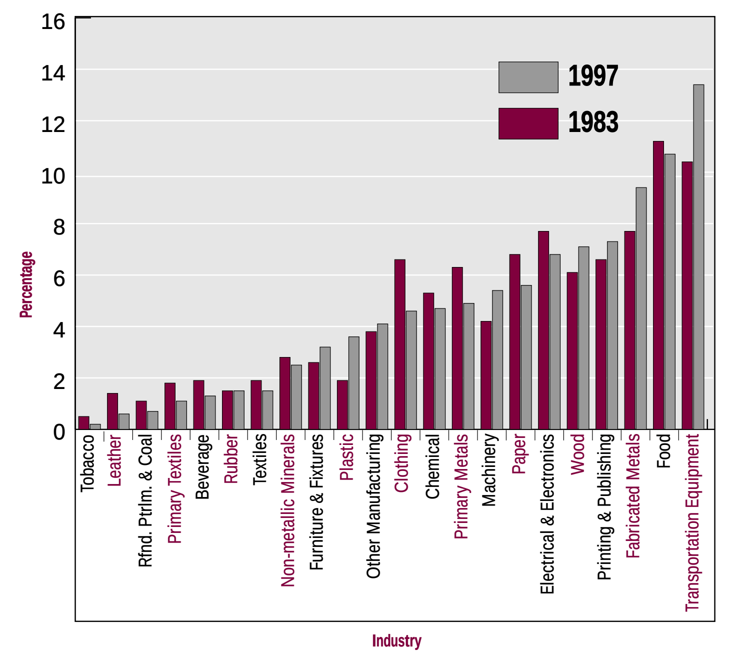
Source: Statistics Canada.

Wood, Machinery, Plastic Products, Fabricated Metal Products, and Transportation Equipment all increased their share of manufacturing employment from 1983 to 1997, as shown in Figures 8 and 9. Transportation Equipment increased its share by about three percentage points, becoming the only industry in the top five employers with comparatively strong labour productivity growth.

### Employees per Establishment

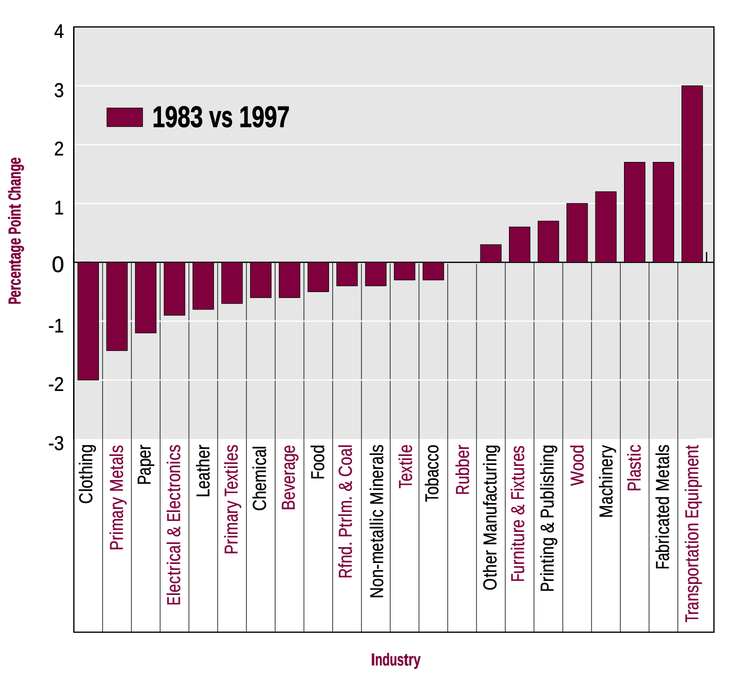
As a rough substitute for establishment employment data, a ratio of industry employment to establishments was used to reveal possible changes in employee concentration or establishment size (based on employment size). Using this proxy, it is observed in Table 18 that from 1983 to 1997, this ratio increased at an average yearly rate of 0.86%, increasing from 47 to 53 employees per establishment, but there were 11 industries with negative

**Figure 8: Share of Total Manufacturing Employment by Industy**




Source: Statistics Canada Based on Establishment's Total Activity.

**Figure 9: Changes in Share of Total Manufacturing Employment by Industry**




Source: Statistics Canada Based on Establishment's Total Activity.

growth rates. In 1997, there were also 11 industries with ratios above the total manufacturing average; of these, eight experienced declines in size and eight had higher-than-average labour productivity growth rates. Of the eight industries with averages of more than 80 employees per establishment, all had productivity growth rates above the total manufacturing average but two, Beverage and Transportation, experienced an increase in the ratio. As a group, industries with a more concentrated distribution of employees per establishment are characterized by superior productivity performance (possibly due to economies of scale, greater propensity for advanced technology adoption, etc.), but may still have room for further rationalization in the use of labour resources and increasing efficiency, given that they experienced declines in their employee:establishment ratios over the 1990s. Of the 11 industries with decreasing ratios, only Transportation Equipment (–2.3%) and Rubber Products (–2.25%) experienced increasing employment levels at 2.53% and 0.53% per year respectively.

## Administrative Employees and Productivity

Administrative employees used to account for a large portion of employment in the manufacturing sector. In 1983, administrative employees accounted for 29% of the total employment in manufacturing; however, some industrial groups had much higher administrative employee shares. For instance, administrative employee share was at 61% in Refined Petroleum and Coal, followed by Chemical and Chemical Products at 48%, and Beverage at 46%. Clothing had the least administrative employee share at only 12% in 1983, followed by Leather and Allied Products at 14% and Wood at 16%.

As technology adoption spreads, many administrative employees were replaced by computers and their share to total employment has generally declined. For instance, the administrative employee share to total employment in the manufacturing sector decreased from 29% in 1983 to about 23% by 1997. Of the 22 industrial groups within the manufacturing sector, with the exceptions of Beverage, Tobacco Products, Leather and Allied Products, Clothing, and Printing, Publishing and Allied, the other 17 industrial groups all experienced a decline

**Table 18: Comparison of Manufacturing Industries' Average of Employees per Establishment Levels**

| Industries by 2-Digit SIC Level | Year 1983 | 1990 | 1997 | Average Annual Growth Rate 1983–1997 (%) | Average Annual Labour Productivity Growth (%) |
|---|---|---|---|---|---|
| Other Manufacturing | 21 | 21 | 25 | 1.25 | 1.0 |
| Non-metallic Mineral | 30 | 32 | 28 | –0.49 | 1.3 |
| Printing & Publishing | 21 | 26 | 28 | 2.08 | –0.6 |
| Fabricated Metal | 25 | 28 | 30 | 1.31 | –0.1 |
| Textiles | 37 | 37 | 37 | 0.00 | 1.1 |
| Wood | 30 | 34 | 43 | 2.61 | 1.2 |
| Furniture & Fixtures | 26 | 30 | 44 | 3.83 | 1.0 |
| Machinery | 42 | 39 | 48 | 0.96 | 1.3 |
| Clothing | 46 | 37 | 50 | 0.60 | 2.4 |
| Plastic | 31 | 40 | 51 | 3.62 | 0.1 |
| Leather & Allied | 59 | 49 | 52 | –0.90 | 1.0 |
| Total Manufacturing | 47 | 47 | 53 | 0.86 | 1.7 |
| Chemical | 71 | 65 | 63 | –0.85 | 1.5 |
| Food | 58 | 58 | 64 | 0.71 | 0.1 |
| Refined Petroleum & Coal | 144 | 115 | 69 | –5.12 | 1.4 |
| Electrical & Electronics | 103 | 87 | 83 | –1.53 | 5.7 |
| Primary Textiles | 135 | 93 | 116 | –1.08 | 3.2 |
| Beverage | 107 | 92 | 120 | 0.82 | 3.4 |
| Rubber | 172 | 139 | 125 | –2.25 | 2.3 |
| Paper & Allied Products | 170 | 158 | 150 | –0.89 | 2.2 |
| Transportation | 129 | 148 | 164 | 1.73 | 3.1 |
| Primary Metal | 246 | 204 | 197 | –1.57 | 3.6 |
| Tobacco | 324 | 274 | 234 | –2.30 | 3.9 |

Source: Statistics Canada.

of administrative employee share over the period 1983 to 1997.

Are those industrial groups with reduced administrative employee share experiencing increased labour productivity growth? To answer this question, we recalculated labour productivity on the basis of total activity, rather than manufacturing activity which is used in this study. This is because administrative employees are counted as a part of employment only under total activity, according to Statistics Canada data.

Table 19 presents the evolution of administrative employee share in employment for all 22 industry groups along with labour productivity growth rates for shipments and value-added per hour worked. It is interesting to note that with the exceptions of Beverage, Tobacco Products, and Clothing, all other industries did have increased labour productivity with declining administrative employee share. This is particularly significant for some high-technology industries, such as Electrical and Electronic Products, Transportation Equipment, Refined Petroleum and Coal Products, Chemical and Chemical Products, and Machinery.

## Table 19: Administrative Employees' Share in Employment and Labour Productivity (1992 dollars)

| Industries by 2-Digit SIC Level | Year 1983 | 1990 | 1997 | % Point Change | Productivity Growth Rate (Based on total shipments & other revenues) | Productivity Growth Rate (Based on total activity value-added) |
|---|---|---|---|---|---|---|
| Food | 31% | 28% | 22% | –9% | 0.53 | 1.55 |
| Beverage | 46% | 43% | 51% | 5% | 2.63 | 2.70 |
| Tobacco | 39% | 44% | 44% | 5% | 6.44 | 5.68 |
| Rubber | 30% | 29% | 25% | –5% | 5.90 | 4.46 |
| Plastic | 21% | 20% | 16% | –5% | 0.71 | 1.34 |
| Leather & Allied | 14% | 14% | 17% | 3% | 0.79 | 0.11 |
| Primary Textiles | 23% | 24% | 21% | –2% | 4.11 | 4.49 |
| Textiles | 21% | 17% | 18% | –3% | 1.50 | 1.66 |
| Clothing | 12% | 14% | 15% | 3% | 2.65 | 2.57 |
| Wood | 16% | 15% | 14% | –2% | 1.68 | 0.84 |
| Furniture & Fixtures | 18% | 13% | 15% | –3% | 1.55 | 1.27 |
| Paper & Allied | 24% | 25% | 22% | –2% | 2.85 | 3.19 |
| Printing & Publishing | 42% | 40% | 44% | 2% | –0.59 | –0.65 |
| Primary Metal | 26% | 25% | 20% | –6% | 4.50 | 4.27 |
| Fabricated Metal | 24% | 18% | 17% | –7% | 0.50 | 0.90 |
| Machinery | 33% | 25% | 23% | –10% | 2.03 | 2.28 |
| Transportation Equipment | 25% | 23% | 20% | –5% | 2.77 | 2.75 |
| Electrical & Electronics | 39% | 33% | 30% | –9% | 5.83 | 4.59 |
| Non-metallic Mineral | 28% | 20% | 21% | –7% | 2.32 | 2.43 |
| Refined Petroleum & Coal | 61% | 57% | 54% | –7% | 2.74 | 2.46 |
| Chemical | 48% | 47% | 40% | –8% | 2.60 | 3.66 |
| Other Manufacturing | 30% | 20% | 23% | –7% | 1.11 | 2.05 |
| **Total Manufacturing** | **29%** | **26%** | **23%** | **–6%** | **2.29** | **2.62** |

Source: Statistics Canada.

Between 1983 and 1997, Beverage, Tobacco Products, and Clothing experienced increased labour productivity with strong increases in administrative employee share.

### Establishment Size and Productivity

Establishment size is often cited as a characteristic or a factor in explaining differences in the productivity performance of manufacturing establishments, industries, and the sector as a whole. Therefore, we estimated labour productivity levels and growth rates for 18 industrial groups (for which complete or partial data were available for the first and last year of the period covered) to examine whether a correlation between establishment size and productivity does exist on an aggregate level. With the data available, it was possible to classify establishments by employment levels as small (1–99), medium (100–199), and large (200+) and to then calcu-

**Table 20: Manufacturing Industries' Labour Productivity by Establishment Employment Size, Based on Constant Dollar (1992) Shipment Data**

| Industries by 2-Digit SIC Level | 1984 Sm. | 1984 Med. | 1984 Large | 1997 Sm. | 1997 Med. | 1997 Large |
|---|---|---|---|---|---|---|
| Food | 144 | 160 | 128 | 148 | 137 | 134 |
| Beverage | x | x | 156 | x | x | 290 |
| Tobacco | x | x | x | x | x | x |
| Rubber | 67 | 64 | 76 | 78 | 85 | 99 |
| Plastic | 71 | x | x | 68 | x | x |
| Leather & Allied | x | x | x | x | x | x |
| Primary Textiles | 73 | x | x | 105 | x | x |
| Textiles | 41 | 66 | 68 | 50 | 63 | 92 |
| Clothing | 33 | 29 | 32 | 47 | 39 | 43 |
| Wood | 60 | 83 | 82 | 59 | 98 | 94 |
| Furniture & Fixtures | 46 | x | x | 44 | x | x |
| Paper & Allied | 82 | 99 | 112 | 89 | 131 | 154 |
| Printing & Publishing | 76 | x | x | 64 | x | x |
| Primary Metal | 81 | 106 | 96 | 132 | 144 | 147 |
| Fabricated Metal | 61 | 85 | 82 | 57 | 85 | 90 |
| Machinery | 73 | 79 | 101 | 76 | 94 | 132 |
| Transportation Equipment | 59 | 75 | 146 | 68 | 89 | 221 |
| Electrical & Electronics | 62 | 71 | 82 | 84 | 111 | 208 |
| Non-metallic Mineral | 78 | 98 | 85 | 86 | 141 | 97 |
| Refined Petroleum & Coal | x | x | 1334 | x | x | 1888 |
| Chemical | x | x | x | x | x | x |
| Other Manufacturing | x | x | x | x | x | x |

Source: Statistics Canada.

**Table 21: Manufacturing Industries' Labour Productivity Average Annual Growth Rates by Establishment Employment Size, Based on Constant Dollar (1992) Shipment Data**

| Industries by 2-Digit SIC Level | Average Annual Growth Rates, 1984 to 1997 (%) Small | Medium | Large |
|---|---|---|---|
| Food | 0.2 | –1.2 | 0.4 |
| Beverage | x | x | 4.9 |
| Tobacco | x | x | x |
| Rubber | 1.2 | 2.2 | 2.1 |
| Plastic | –0.3 | x | x |
| Leather & Allied | x | x | x |
| Primary Textiles | 2.8 | x | x |
| Textiles | 1.5 | –0.4 | 2.4 |
| Clothing | 2.8 | 2.3 | 2.3 |
| Wood | –0.1 | 1.3 | 1.1 |
| Furniture & Fixtures | –0.3 | x | x |
| Paper & Allied | 0.6 | 2.2 | 2.5 |
| Printing & Publishing | –0.1 | x | x |
| Primary Metal | 3.8 | 2.4 | 3.3 |
| Fabricated Metal | –0.5 | 0.0 | 0.8 |
| Machinery | 0.3 | 1.3 | 2.1 |
| Transportation Equipment | 1.1 | 1.3 | 3.2 |
| Electrical & Electronics | 2.4 | 3.5 | 7.4 |
| Non-metallic Mineral | 0.8 | 2.8 | 1.0 |
| Refined Petroleum & Coal | x | x | 2.7 |
| Chemical | x | x | x |
| Other Manufacturing | x | x | x |

Source: Statistics Canada.

late labour productivity in real 1992-based dollars using employment and shipments at the production level.

As shown in Table 20, of the 12 industrial groups for which complete data exist from 1984 to 1997, 10 exhibited a positive relationship between size and productivity levels within an industry when comparing small to medium or large. Large, however, did not always have the highest productivity level in these cases. With respect to growth rates, only five of the 12 seemed to have a positive correlation between average annual productivity growth rates and establishment size over this period, as seen in Table 21.

A summary by industrial group can be found in Appendix 2.

## Destinations of Manufacturing Shipments

### Exports to Outside Canada

A large portion of manufacturing shipments has been exported to other countries. According to statistics, the manufacturing sector posted $406 billion in shipments in 1996. Of total shipments, about $159 billion or 39% were exported outside Canada. The share of exports to total manufacturing shipments expanded gradually from 27% in 1984, to 31% in 1990, to 37% in 1993.

An examination of the export market showed that the United States continued to be the major destination for Canadian manufacturing products, increasing from $97 billion in 1993 to $131 billion by 1996. However, the export market has also seen a 57% increase in shipments to other foreign destinations, from $18 to $28 billion during the same period. This, in part, showed the widening foreign market base resulting from trade liberalization, declines in transportation costs, and increased globalization.

Canada's merchandise trade exports were $280 billion in 1996; the manufacturing sector's contribution was about 57% (= 159/280).

A preliminary estimate of value of manufacturing shipments destined for exports in 1997 is $175 billion, which is expected to account for 40% of the total shipments of the manufacturing sector and 58% of total merchandise exports.

### Exports to Outside Canada by Industrial Group

Canadian manufacturing exports came mainly from Transportation Equipment with $53 billion in 1996, accounting for 33% of the total. Paper and Allied Products was second with $19 billion or about 12% of total manufacturing exports. The combined export share of these top two industries, however, decreased from over half of the total manufacturing exports in 1993 to about 45% in 1996. The other major exporters in 1996 were Electrical and Electronic Products with $17 billion, Wood with $12 billion, and Primary Metal with $11 billion. The total exports of these top five industrial groups accounted for 70% of manufacturing exports in 1996.

The decline of export share of Transportation Equipment was attributed mainly to slower export growth in this industrial group relative to other manufacturing industries. The share of export, which has been over 70% since 1984, dropped to 61% in 1996. As indicated in Table 22, this major industrial group posted one of the largest declines in export share between 1984 and 1996.

Paper and Allied Products, on the other hand, increased its export share to 62%, the highest posted by any major industrial group in 1996. Another significant increase came from Electrical and Electronic Products whose share of exports rose from 31% in 1984 to 59% by 1996. It is worth noting that the export share of Primary Textile industries has significantly increased from only

**Table 22: Comparison of Shares of Exports to Shipments by Manufacturing Industries (percentage)**

| Industries by 2-Digit SIC Level | 1984 (%) | 1990 (%) | 1993 (%) | 1996 (%) |
|---|---|---|---|---|
| Food | 8 | 9 | 10 | 14 |
| Beverage | 11 | 12 | 14 | 16 |
| Tobacco | – | 8 | 20 | 5 |
| Rubber | 26 | 43 | 54 | 41 |
| Plastic | 9 | 15 | 19 | 24 |
| Leather & Allied | – | 12 | 16 | 25 |
| Primary Textile | 9 | 20 | 31 | 44 |
| Textile | 5 | 10 | 16 | 21 |
| Clothing | 3 | 4 | 8 | 15 |
| Wood | 36 | 37 | 46 | 49 |
| Furniture & Fixtures | 10 | 15 | 24 | 34 |
| Paper & Allied | 52 | 55 | 58 | 62 |
| Printing & Publishing | 2 | 3 | 6 | 8 |
| Primary Metal | 31 | 39 | 41 | 42 |
| Fabricated Metal | 15 | 14 | 21 | 25 |
| Machinery | 30 | 34 | 42 | 47 |
| Transportation Equipment | 72 | 70 | 74 | 61 |
| Electrical & Electronic | 31 | 34 | 47 | 59 |
| Non-metallic Mineral | 12 | 11 | 16 | 22 |
| Refined Petroleum & Coal | 5 | 8 | 11 | 11 |
| Chemical | 13 | 23 | 23 | 31 |
| Other Manufacturing | 13 | 17 | 28 | 33 |
| **Total Manufacturing** | **27** | **31** | **37** | **39** |

9% in 1984 to 44% in 1996, indicating a remarkable growth rate of more than 14% annually.

Other industrial groups that were closely tied with export markets in 1996 included Wood, Machinery, Primary Textile, Primary Metal, and Rubber Products. Their export shares were all greater than the average, 39%, of the manufacturing sector.

On the contrary, major industrial groups such as Tobacco Products, Printing, Publishing and Allied, Refined Petroleum and Coal Products, Food, Clothing, and Beverage comprised the industries that were highly oriented toward local markets.

### Intra-provincial Trade

The decrease in the percentage of total shipments to markets within the province of origin persisted in 1996. Only eight out of the 22 industrial groups had manufacturing shipments where more than half stayed in the producing province. Rubber Products, Transportation Equipment, and Tobacco Products were the only industrial groups which reported an increase in in-province shipments between 1993 and 1996. This was consistent with the trend observed since 1984 that most manufacturing products were more likely to be destined for markets away from the province where they were produced.

The highest percentage of in-province shipments between 1993 and 1996 were Printing, Publishing and Allied, Beverage, and Non-metallic Mineral Products. In particular, in-province shipments for the top two industries made up over 70% of the industry's total manufacturing shipments.

### Interprovincial Trade

Analysis of the trends between 1984 and 1996 indicated that the share of manufacturing products sold to Canadian provinces other than the place of origin has been increasing for most provinces. Between 1993 and 1996, there were only four provinces – Prince Edward Island, New Brunswick, Quebec and Ontario – where the share of trade to other provinces declined. During the same period, New Brunswick had the highest share of domestic shipments to other parts of Canada with 54%, followed by Manitoba with 50%, and Prince Edward Island with 46%. The lowest shares of interprovincial shipments, on the other hand, were Newfoundland with 19%, Ontario with 20%, and British Columbia with 23%.

As the market for Canadian manufacturing products continued to grow, manufacturing shipments were more often destined for markets outside their province of origin. The majority of the provinces and industrial groups experienced a boost in the value of foreign exports as well as interprovincial trade for 1996. In particular, the increase in the propensity to export outside Canada was supported by fewer trade barriers as well as lower exchange rates for the Canadian dollar.

## Performance of Production Costs in the Manufacturing Sector

### Aggregate Manufacturing Sector Total Costs

During the past decade, the Canadian manufacturing sector has had to overcome major challenges, including the FTA in 1989, NAFTA in 1994, and globalization, in order to stay competitive on both the Canadian and international markets. How have industries adapted to meet these challenges? Competitiveness depends on increased productivity, and this can be achieved only by rationalizing product costs. In this section, an attempt will be made to explain how and to what extent the manufacturing sector has rationalized its product costs. For this purpose, we will examine expenditures on overall product costs and their components as they evolve over time and how they influence productivity. The data used in this section, including production costs, shipment values and growth rates, are based on the current dollar. This should not pose a problem here – we are interested in making relative comparisons in the evolution of costs and shipments, and between industries, and not in absolute values. Furthermore, the period being examined from 1983 to 1997 leaves out the dramatic fluctuations in inflation that worked their way through the economy during the 1970s and early 1980s.

In 1983, the ratio of total production costs to shipments and other revenue values (hereon referred to as shipments) was 82% for total manufacturing; this had fallen to 78% in 1997. While shipments rose by an average annual compound rate of 5.6%, costs increased by only 5.2% per year. All three of the main cost components grew at a slower rate, but it was the slower rate for the wages and salaries component that accounted for most of the decline.

The wages and salaries component ratio to shipments was 17.1% while its share of total costs was 21%. Between 1983 and 1997, this component increased at an average annual rate of 4.3%, less than shipments growth. The ratio of the wages and salaries component to shipments fell to 14.3% in 1997. Similarly, its share of total cost also fell to 18% by 1997.

The energy and fuel component accounted for only 3% of total costs in 1983 and its ratio to shipments was 2.9%. Over the 14-year time span, energy and fuel costs grew at an average annual rate of 3.1%, less than the growth rates for total costs (5.2%) and shipments (5.6%). This gap was significant, but due to its relatively small share of costs the final impact on total costs was small. By 1997, its share of total costs remained at around 3% while its ratio to shipments fell to 2.1% from 3% in 1983.

Materials and supplies make up the largest section of total costs and have the largest ratio to shipment values. The ratio to shipments was about 62% in 1983 and remained essentially unchanged at 61.4% in 1997. During this period, materials and supplies costs increased at an average annual rate of 5.5%, slightly below that of shipments but greater than wages and salaries, and energy and fuel, thereby increasing its share of costs to 79% by 1997, up three percentage points from 1983.

In a static situation, it would be expected that materials and supplies use would increase at the same pace as shipments if factors such as the ratios of inputs to outputs remain stable for specific outputs. Given the magnitude of the materials and supplies component, even a relatively small change in rates can have a significant impact on total costs. Therefore, given that this component's ratio to shipments has not really changed for the sector as a whole, it would be interesting and possibly very useful to examine whether there have been developments in technology and processes that could raise the efficiency with which these resources are utilized. Similarly, an examination of industries and establishments with a declining materials and supplies component, together with a study of materials and supplies, and prices, may also provide insights into this area. Increasing the efficiency of labour together with materials and supplies use could have a large effect on total costs and productivity.

### Differences in Inter-Industry Total Costs Evolution

A review of individual industry groups' total costs to shipments ratios reveals that significant industry differences exist. Beverage, Tobacco Products, Chemical and Chemical Products, Printing, Publishing and Allied, and Non-metallic Mineral Products had the lowest total costs to shipments ratio as of 1997, at 59%, 63%, 68%, 68%, and 70%, in contrast to 78% for total manufacturing. Of these five, Chemical and Chemical Products had the largest percentage point drop in the total cost to shipments ratio, falling eight percentage points from 1983 to 1997, versus a four percentage point drop by total manufacturing.

On the other side of the spectrum, the five industrial groups with ratios of total costs to shipments greater than the total manufacturing ratio – Rubber Products, Wood, Leather and Allied Products, Transportation Equipment, and Refined Petroleum and Coal Products – had the highest ratios.

Large decreases in total costs relative to shipments were also observed for the following industries: Primary Textiles, Paper and Allied Products, and Other Manufacturing.

Not all industrial groups had total costs to shipments ratios that varied significantly from the total manufacturing sector's ratio, nor did they all experience dramatic declines or increases, but there have been significant relative cost component movements. Therefore, the remaining industrial groups were examined to identify any important trends or characteristics for Electrical and Electronics Products, Fabricated Metal Products, Machinery, Plastic Products, Clothing, Food, Furniture and Fixtures, and Primary Metal.

See Appendix 3 for further discussion on the differences in total costs to shipments ratios for the individual industries.

### Cost Components vs Shipments Growth Summary

**Total Costs:** For the manufacturing sector, total costs increased more slowly than shipments, expanding at a rate of 0.37% percentage points less per year than shipments growth. Table 23 reveals that 13 industrial groups had total cost average annual growth rates which expanded at an even lower rate relative to shipments. Two industries had total costs that actually outpaced their shipments growth: Leather and Allied Products, and Refined Petroleum and Coal Products.

The five industries with the fastest decline in total costs relative to shipments were Chemical and Chemical Products, Other Manufacturing, Primary Textiles, Paper and Allied Products, and Tobacco Products, with average annual growth rates for shipments growing 0.82, 0.72, 0.71, 0.66, and 0.66 percentage points faster than total cost growth rates. The five that decreased relative costs the slowest or increased them were Printing, Publishing and Allied, Rubber Products, Electrical and Electronics Products, Leather and Allied Products, and Refined Petroleum and Coal Products. The first three had total cost annual rates 0.17, 0.11, and 0 percentage points less than shipments growth rates, while the last two had costs that actually outpaced shipment rates by 0.09 and 0.16 percentage points annually.

**Wages and Salaries:** This component grew on average 4.3% per year, 1.3 percentage points less than shipments, thus falling behind for the sector as a whole. Transportation Equipment, Tobacco Products, Rubber Products, Electrical and Electronic Products, and Wood Products were the groups with the wage components experiencing the largest relative declines. Their wage components grew at rates of 7.34, 6.48, 3.85, 3.38 and 2.99 percentage points less than shipments rates respectively.

Other Manufacturing, Fabricated Metal Products, and Plastic Products had annual wage component growth rates that were 0.43, 0.21, and 0.15 percentage points less than shipments growth rates. Textile Products, and Refined Petroleum and Coal Products had rates 0.08 and 1.49 percentage points greater than shipments growth rates.

**Energy and Fuel:** This component also decreased for manufacturing as a whole, while nine industrial groups had energy and fuel components that fell even faster than for total manufacturing. Five industries where energy and fuel costs lost the most ground were Tobacco Products, Rubber Products, Chemical and Chemical Products, Beverage, and Electrical and Electronics Products. The energy and fuel costs annual growth rates were 6.9, 5.8, 4.6, 4.5, and 3.9 percentage points less than shipments growth rates. Interestingly, as a group these industries were characterized by greater than average labour productivity growth.

Leather and Allied Products, Primary Metal, Clothing, and Printing, Publishing and Allied did not have such improvements, with growth rates of only 0.63, 0.57, 0.28, and 0.20 percentage points less than shipments growth. Refined Petroleum and Coal Products energy costs grew at a rate 2.3 percentage points higher on average per year.

**Materials and Supplies:** Although this component also expanded more slowly than shipments for total manufacturing, it was a minor rate difference at 0.05 percentage points per year. Only seven of the 22 industrial groups

**Table 23: Ratios of Total Activity Costs to Shipments in the Manufacturing Sector**

| Industries by 2-Digit SIC Level | Total Costs (%) | | Wages & Salaries (%) | | Energy & Fuel (%) | | Materials & Supplies (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1983 | 1997 | 1983 | 1997 | 1983 | 1997 | 1983 | 1997 |
| Leather & Allied | 81 | 82 | 26.9 | 23.6 | 1.1 | 1.0 | 53.3 | 57.8 |
| Refined Petroleum & Coal | 91 | 93 | 3.1 | 3.8 | 1.2 | 1.6 | 87.0 | 88.0 |
| Clothing | 80 | 75 | 28.9 | 24.0 | 0.7 | 0.7 | 50.4 | 50.7 |
| Primary Textiles | 81 | 74 | 20.5 | 16.2 | 3.5 | 2.5 | 57.3 | 55.0 |
| Textile Products | 78 | 77 | 20.4 | 20.4 | 2.5 | 1.9 | 55.5 | 54.4 |
| Beverage | 64 | 59 | 18.2 | 13.7 | 2.1 | 1.1 | 43.6 | 44.2 |
| Food | 85 | 80 | 11.5 | 10.9 | 1.6 | 1.3 | 71.6 | 68.0 |
| Non-metallic Mineral | 75 | 70 | 23.0 | 19.4 | 9.0 | 5.9 | 42.6 | 44.5 |
| Other Manufacturing | 78 | 71 | 24.4 | 23.1 | 1.1 | 0.9 | 52.0 | 46.5 |
| Chemical | 76 | 68 | 13.2 | 10.8 | 6.3 | 3.4 | 56.3 | 53.8 |
| Paper & Allied | 83 | 76 | 21.2 | 15.9 | 10.1 | 8.0 | 52.1 | 52.4 |
| Primary Metal | 83 | 78 | 22.7 | 15.9 | 6.8 | 6.3 | 53.3 | 55.7 |
| Total Manufacturing | 82 | 78 | 17.1 | 14.3 | 2.9 | 2.1 | 61.9 | 61.4 |
| Fabricated Metal | 79 | 77 | 25.1 | 24.4 | 1.7 | 1.5 | 52.5 | 50.9 |
| Printing & Publishing | 70 | 68 | 31.9 | 29.8 | 0.8 | 0.8 | 37.1 | 37.7 |
| Furniture & Fixtures | 78 | 75 | 27.9 | 23.6 | 1.4 | 1.1 | 48.3 | 50.7 |
| Tobacco | 68 | 63 | 15.0 | 6.5 | 0.7 | 0.2 | 52.8 | 56.3 |
| Electrical & Electronics | 77 | 75 | 25.0 | 15.6 | 1.0 | 0.6 | 50.9 | 58.7 |
| Wood | 85 | 81 | 25.1 | 17.0 | 3.3 | 2.2 | 57 | 61.5 |
| Machinery | 78 | 74 | 24.6 | 20.2 | 1.2 | 0.8 | 52.2 | 53.2 |
| Rubber | 81 | 80 | 21.9 | 13.2 | 2.3 | 1.1 | 56.7 | 65.6 |
| Transportation Equipment | 85 | 83 | 12.0 | 9.4 | 0.8 | 0.5 | 72.3 | 73.3 |
| Plastic | 79 | 74 | 19.4 | 19.0 | 2.3 | 2.1 | 57.3 | 53.3 |

had a better performance, while 14 were actually characterized by materials and supplies costs growth that outpaced shipments growth.

Other Manufacturing, Primary Textiles, Food, Chemical and Chemical Products, and Plastic Products had annual rates 0.88, 0.53, 0.37, 0.36, and 0.36 percentage points less than shipments growth. Furniture and Fixtures, Tobacco Products, Leather and Allied Products, Rubber Products, and Electrical and Electronics Products had supplies costs that outpaced shipments growth rates by 0.63, 0.89, 1.08, 1.13, and 1.24 percentage points respectively.

## Capital Investment in the Manufacturing Sector

Capital investment is probably the most important factor in determining labour productivity level and growth. The more capital available, the more firms can invest in advanced technologies. Increased use of more advanced technologies enables increases in output which results in higher labour productivity level and growth.

### Capital Labour Ratio

As shown in Table 24, between 1983 and 1997, the average annual growth rate of capital per person employed (based on all capital components in 1992 constant dollars) was 0.57%. This was the result of a positive gap between the growth of net capital stock and employment levels which both grew over this period. Of the 22 industries reviewed, eight had annual rates that were below that for total manufacturing, while six actually declined over time. These six were Chemical and Chemical Products, Non-metallic Mineral Products,

**Table 24: Ratio of Real Net Capital Stock to Persons Employed – Constant 1992 Dollars**

| Industries by 2-Digit SIC Level | Year | | Average Annual Growth Rate 1983–1997 (%) | Average Annual Labour Productivity Growth Rate (%) |
|---|---|---|---|---|
| | 1983 | 1997 | | |
| Chemical | 193 770 | 142 607 | –2.17 | 1.50 |
| Non-metallic Mineral | 75 277 | 57 386 | –1.92 | 1.30 |
| Fabricated Metal | 23 730 | 20 122 | –1.17 | –0.10 |
| Machinery | 23 420 | 20 677 | –0.89 | 1.30 |
| Refined Petroleum & Coal | 529 677 | 498 616 | –0.43 | 1.40 |
| Rubber | 59 136 | 57 947 | –0.15 | 2.30 |
| Wood | 41 874 | 42 760 | 0.15 | 1.20 |
| Furniture & Fixtures | 11 732 | 12 328 | 0.36 | 1.00 |
| Total Manufacturing | 60 756 | 65 822 | 0.57 | 1.70 |
| Plastic | 30 530 | 33 758 | 0.72 | 0.10 |
| Textiles | 15 258 | 17 010 | 0.78 | 1.10 |
| Food | 40 272 | 45 820 | 0.93 | 0.10 |
| Beverage | 79 430 | 92 278 | 1.08 | 3.40 |
| Primary Metal | 145 470 | 186 286 | 1.78 | 3.60 |
| Electrical & Electronics | 24 298 | 32 326 | 2.06 | 5.70 |
| Primary Textiles | 39 870 | 57 194 | 2.61 | 3.20 |
| Other Manufacturing | 16 265 | 23 745 | 2.74 | 1.00 |
| Printing & Publishing | 17 667 | 25 831 | 2.75 | -0.60 |
| Transportation Equipment | 46 596 | 68 925 | 2.84 | 3.10 |
| Leather & Allied | 10 873 | 18 813 | 3.99 | 1.00 |
| Clothing | 4 426 | 7 700 | 4.03 | 2.40 |
| Paper & Allied | 145 905 | 263 654 | 4.32 | 2.20 |
| Tobacco | 49 618 | 98 293 | 5.00 | 3.90 |

Source: Statistics Canada.

Fabricated Metal Products, Machinery, Refined Petroleum and Coal Products, and Rubber Products with rates of –2.17%, –1.92%, –1.17%, –0.89%, –0.43%, and –0.15% per year respectively. Interestingly, of the nine industrial groups characterized by productivity growth rates above that for total manufacturing, all had capital labour ratios that expanded significantly faster than for total manufacturing, with the exception of Rubber Products which actually had a negative average annual growth rate. In the case of the rubber industry, it should be noted that both its capital and labour level increased but the growth in persons employed was greater than that for capital stock. The five industrial groups that expanded their capital labour ratio the most were Transportation Equipment (2.84%), Leather and Allied Products (3.99%), Clothing (4.03%), Paper and Allied Products (4.32%), and Tobacco Products (5.0%) per year.

Little information could be retrieved from the data to assess the importance of the composition of capital employed. However, some indication of the possible benefits of technical change embodied in new capital was gained through surveys on the adoption of advanced technology. As a group, when labour productivity growth rate estimates are matched up to the top five industries classified as "high adopters" of advanced technologies (those having adopted at least one or more advanced technologies) and the bottom five "low adopters," we find that those with higher adoption rates are generally characterized by superior labour productivity performance. These results are presented in Table 25.

### Ratio of Capital Stock to Shipments

As shown in Table 26, over the same period the manufacturing sector as a whole experienced declining net capital stock to shipments ratios, falling at an average annual compound rate of –1.5% and ending at a ratio of 0.30 in 1997. Of the 22 individual industries, 14 had ratios that were declining, nine of which were contracting at an even faster rate than for total manufacturing. The five industries with greatest annual rates of decline on average were Rubber Products (–5.8%), Chemical and Chemical Products (–4.7%), Non-metallic

**Table 25: Technology Adoption and Labour Productivity**

| | Using the 1993 Survey Rankings | | | Using the 1998 Survey Rankings | |
|---|---|---|---|---|---|
| | **Industry** | **Labour Productivity Growth Rates*** | | **Industry** | **Labour Productivity Growth Rates*** |
| High Adopters | Electrical & Electronics | 5.70% | High Adopters | Beverages | 3.40% |
| | Paper | 2.20% | | Primary Metals | 3.60% |
| | Machinery | 1.30% | | Electrical & Electronics | 5.70% |
| | Primary Metals | 3.60% | | Primary Textiles | 3.20% |
| | Transportation Equipment | 3.10% | | Paper | 2.20% |
| | **Average** | **3.18%** | | **Average** | **3.62%** |
| Low Adopters | Food | 0.10% | Low Adopters | Clothing | 2.40% |
| | Printing & Publishing | –0.60% | | Furniture & Fixtrures | 1.00% |
| | Wood | 1.20% | | Leather | 1.00% |
| | Textiles & Clothing | 1.10% & 2.40% | | Printing & Publishing | –0.60% |
| | Furniture & Fixtures | 1.00% | | Refined Petroleum & Coal Products | 1.40% |
| | **Average** | **1.04%** | | **Average** | **1.04%** |
| | **Total Manufacturing** | **1.70%** | | **Total Manufacturing** | **1.70%** |

Source: Statistics Canada.

* Average Annual Compound Growth Rates over the Period 1983 to 1997.

Mineral Products (–4.3%), Electrical and Electronics Products (–3.7%), and Refined Petroleum and Coal Products (–3.0%). The five that increased their ratios were Clothing (0.9%), Paper and Allied Products (1.5%), Other Manufacturing (1.6%), Leather and Allied Products (2.9%), and Printing, Publishing and Allied (3.1%). In itself, there was no obvious correlation observed between the estimated labour productivity growth rates and changes in net stock per shipments.

In terms of ranking by ratios, in 1997 there were 16 industrial groups with ratios below that for total manufacturing, with the smallest ratios for Clothing (0.09), Machinery (0.12), Furniture and Fixtures (0.12), Tobacco Products (0.12), and Electrical and Electronic Products (0.13). The five industrial groups with the highest ratios were Non-metallic Mineral Products (0.31), Refined Petroleum and Coal Products (0.34), Chemical and Chemical Products (0.39), Primary Metal (0.73), and Paper and Allied Products (1.04). Again, no obvious relationship to the labour productivity trends was seen.

**Table 26: Ratio of Industries' Real Net Capital Stock to Shipments**

| Industries by 2-Digit SIC Level | Year | | Average Annual Growth Rate 1983–1997 (%) | Average Annual Labour Productivity Growth Rate (%) |
|---|---|---|---|---|
| | 1983 | 1997 | | |
| Clothing | 0.08 | 0.09 | 0.9 | 2.4 |
| Machinery | 0.18 | 0.12 | –2.9 | 1.3 |
| Furniture & Fixtures | 0.14 | 0.12 | –1.1 | 1.0 |
| Tobacco | 0.14 | 0.12 | –1.1 | 3.9 |
| Electrical & Electronics | 0.22 | 0.13 | –3.7 | 5.7 |
| Textiles | 0.15 | 0.14 | –0.5 | 1.1 |
| Fabricated Metal | 0.21 | 0.16 | –1.9 | –0.1 |
| Transportation Equipment | 0.17 | 0.17 | 0.0 | 3.1 |
| Food | 0.17 | 0.18 | 0.5 | 0.1 |
| Rubber | 0.46 | 0.20 | –5.8 | 2.3 |
| Other Manufacturing | 0.16 | 0.20 | 1.6 | 1.0 |
| Leather & Allied | 0.14 | 0.21 | 2.9 | 1.0 |
| Plastic | 0.24 | 0.24 | 0.0 | 0.1 |
| Printing & Publishing | 0.17 | 0.26 | 3.1 | –0.6 |
| Wood | 0.36 | 0.29 | –1.5 | 1.2 |
| Primary Textiles | 0.36 | 0.29 | –1.5 | 3.2 |
| Total Manufacturing | 0.37 | 0.30 | –1.5 | 1.7 |
| Beverage | 0.37 | 0.30 | –1.5 | 3.4 |
| Non-metallic Mineral | 0.57 | 0.31 | –4.3 | 1.3 |
| Refined Petroleum & Coal | 0.52 | 0.34 | –3.0 | 1.4 |
| Chemical | 0.76 | 0.39 | –4.7 | 1.5 |
| Primary Metal | 1.06 | 0.73 | –2.6 | 3.6 |
| Paper & Allied | 0.85 | 1.04 | 1.5 | 2.2 |

Source: Statistics Canada.

### Shares of Capital Investment by Industry

Investment data were available for all industrial groups except for Other Manufacturing, Leather and Allied Products, and Tobacco Products, as seen in Table 27. In 1997, data indicated that Transportation Equipment, Paper and Allied Products, Primary Metal, Chemical and Chemical Products, and Food had the largest shares of total gross fixed capital formation at 22.22%, 15.21%, 11.00%, 10.72%, and 6.80%. The lowest shares were for Textile Products (0.48%), Clothing (0.69%), Furniture and Fixtures (0.94%), Beverage (1.30%), and Rubber Products (1.32%).

When examining changes in relative importance with respect to total investments, looking at the first and last year can be deceiving and may under- or overestimate a trend, given the occurrence of significant annual fluctuations. As a result, emphasis was placed on looking at general trends over the period for the five industries with the largest shares of manufacturing gross fixed capital formation.

Although Refined Petroleum and Coal Products began at 11.24% and closed at 2.02% in 1997, the apparent trend downward was less dramatic in reality given the very high share in 1983; if 1984 had been chosen, the rate of decline would seem far lower although still high and consistent over the period. The Chemical and Chemical Products group also experienced a fairly steady decline with its share falling to 10.72% from 21.1% in 1983. Paper and Allied Products began at 12.87% and ended at 15.21%, but the trend was actually slightly negative or flat over the longer run. Transportation Equipment, on the other hand, increased its share at a steady pace, moving from 9.87% to 22.22%. Finally, the Primary Metal group also had a trend that was actually negative over time, but it reached 11% in 1997, up from 8.64% in 1983.

**Table 27: Share of Total Manufacturing Gross Fixed Capital Formation by Industry**

| Industries by 2-Digit SIC Level | Year | | Avg Annual Labour Productivity Growth Rate (%) |
|---|---|---|---|
| | 1983 (%) | 1997 (%) | |
| Textiles | 0.46 | 0.48 | 1.10 |
| Clothing | 0.63 | 0.69 | 2.40 |
| Furniture & Fixtures | 0.33 | 0.94 | 1.00 |
| Beverage | 3.02 | 1.30 | 3.40 |
| Rubber | 1.26 | 1.32 | 2.30 |
| Primary Textiles | 1.24 | 1.44 | 3.20 |
| Plastic | 0.99 | 1.97 | 0.10 |
| Refined Petroleum & Coal | 11.24 | 2.02 | 1.40 |
| Non-metallic Mineral | 1.78 | 2.22 | 1.30 |
| Machinery | 1.35 | 2.23 | 1.30 |
| Printing & Publishing | 2.15 | 3.23 | –0.60 |
| Fabricated Metal | 2.34 | 4.19 | –0.10 |
| Electrical & Electronics | 6.27 | 4.65 | 5.70 |
| Wood | 3.66 | 4.98 | 1.20 |
| Food | 8.51 | 6.80 | 0.10 |
| Chemical | 21.10 | 10.72 | 1.50 |
| Primary Metal | 8.64 | 11.00 | 3.60 |
| Paper & Allied | 12.87 | 15.21 | 2.20 |
| Transportation Equipment | 9.87 | 22.22 | 3.10 |
| Leather & Allied | x | x | 1.00 |
| Other Manufacturing | x | x | 1.00 |
| Tobacco | x | x | 3.90 |

Source: Statistics Canada.

# Part TWO

## The Use of Advanced Technologies in the Manufacturing Sector

### General Overview

The purpose of this section is to review the use of advanced technologies in the manufacturing process in the hope that it might shed light on why some industries seem to fare better than others. Most of the data analyzed results from two surveys conducted by Statistics Canada. The first survey was conducted in 1993 and was entitled "Survey of Innovation and Advanced Technology" (Baldwin and Sabourin, 1993). This survey was sent to approximately 4,000 Canadian manufacturing establishments. A follow-on survey was conducted in 1998, "Survey of Advanced Technologies in Canadian Manufacturing" (Sabourin and Beckstead, 1999). The survey results, as well as the results of related issues analyzed principally by John Baldwin and David Sabourin from Statistics Canada, are used in the analysis.

In order to assess adoption levels, Statistics Canada developed a set of categories which it used to classify different groups of technology. Technologies were categorized into six functional groups in 1993. These are Design and Engineering, Fabrication and Assembly, Automated Material Handling, Inspection and Communications, Manufacturing Information Systems, and Integration and Control. In all, 22 advanced technologies were distributed within these groups. By 1998, the definition as well as the technologies had evolved. The 1998 definition contained four of the original categories, including Design and Engineering, Fabrication and Assembly, Automated Material Handling, and Integration and Control, and was expanded to include 26 technologies. Two new categories emerged: Communications became Network Communications and Inspection became a category of its own. Manufacturing Information Systems was included as part of Integration and Control.

### Advanced Technologies and Their Functional Groups

The technologies within the Design and Engineering group comprise computer-aided design (CAD), computer-aided engineering (CAE) and computer-aided manufacturing (CAM). The 1998 definition also added modeling and simulation technologies and the electronic exchange of CAD files.

The Fabrication and Assembly group addresses flexible manufacturing systems and associated equipment. Included in this grouping are numerically controlled and computer numerically controlled machines. This category also includes robotics and material working lasers. Two of the newly emerging technologies, rapid prototyping and near net shape technologies, were added in 1998 as was programmable logic controllers.

The Automated Material Handling group contained three technologies between the two time periods: automated storage and retrieval systems, automated guided vehicle systems, and parts identification for manufacturing automation.

In 1993, the Inspection and Communications group was the largest. The inspection portion contained automated inspection equipment for incoming materials and for final products. These technologies remain in the Inspection-only group defined in 1998. The communications portion addressed communication networks both within and outside the manufacturing establishment. These communication networks include local area networks (LANs) for technical data and for factory use and inter-company computer networks (WANs). By 1998, these communication technologies became a category on their own entitled Network Communications.

The Integration and Control group contains those technologies used to integrate a number of automated machines/processes. Specific technologies are supervisory control and data acquisition systems, digital remote control process plant control, knowledge-based software systems, and computer integrated manufacturing systems. In 1998, manufacturing resource planning systems was moved into this category. (It had been on its own in 1993 but was incorporated into this grouping by 1998.)

The analysis that follows highlights differences in adoption rates between the functional groups that were essentially the same in both surveys (based on the establishment weighted data) as well as focuses on the current rates of adoption.The analysis provided in tables for these groups may be used to provide a proxy of the differences in adoption rates.

While direct comparisons are provided, Statistic Canada changed its sampling methodology between 1993 and 1998. In 1998, it only surveyed firms with more than 10 employees; thus, the numbers from 1998 may be a little inflated compared to those in 1993. As well, the technologies shifted between groups and changed over time. The majority of the analysis presented reflects preadjusted data. However, several tables have been modified by Statistics Canada which take into account the differences in methodology. In these tables, direct comparison may be made; where this occurs, these tables will be explicitly identified.

### Comparison of 1993 and 1998 Technology Adoption by Functional Group

In 1993, the technology group with the highest adoption rate was Design and Engineering (see Table 28). In this group, the leading technology was CAD/CAE. The reasons indicated for the high adoption rates in this category were the result of the sharply falling costs of computers and software. The hardware and software costs associated with running PC-based systems had become significantly less than using mainframe or mini-computer versions to perform design and engineering functions.

Fabrication and Assembly was the group with the third highest adoption rate in 1993. In this group one technology led – numerically controlled and computer numerically controlled machines. The functional group with the third highest rate of adoption in1993 was Integration and Control.

In contrast, the 1998 survey results indicate that establishments had adopted a core of technologies as opposed to focusing on one functional group. The leading technologies across all industries were CAD/CAE, CAD/CAM, programmable logic controllers, LANs and company wide computer networks. The CAD/CAE and CAD/CAM technologies represent the Design and Engineering group. Programmable logic controllers are contained in the Fabrication and Assembly group. Finally, the local area network and company-wide network technologies are contained in the Network Communications category, which was a new category defined in 1998.

Three other technologies had moderately high adoption rates across many industries. These were reported as inter-company computer networks, factory floor computers, and inspection data used in manufacturing controls. WANS were a leading technology in most industries. Factory floor computers were also very important in many industries.

### Rank Order of Technologies by Functional Group

A direct comparison may be made of the rank order of functional groups between the 1993 and 1998 survey results. (The percentages are establishment weighted and thus indicate the percentage of Canadian establishments that have adopted at least one technology per group.)

While Design and Engineering led in adoption rates from 1993 to 1998, what perhaps is surprising is the jump that Integration and Control technologies made to second place – a 49% adoption rate by 1998. Technologies in this category were: manufacturing resource planning, computers used for control on the factory floor, computer integrated manufacturing, supervisory control and data acquisition, and use of inspection data for manufacturing control. The significant increase in adoption of these technologies points to considerable automation being achieved on the shop floor. In addition to this

**Table 28: Functional Technology Use (percentage of establishments)**

| Functional Group | 1993 (%) | Functional Group | 1998 (%) |
|---|---|---|---|
| Design & Engineering | 34 | Design & Engineering | 51 |
| Inspection & Communication | 10 | Integration & Control | 49 |
| Fabrication & Assembly | 25 | Network Communications | 47 |
| Manufacturing Info Systems | 10.5 | Process, Fabrication & Assembly | 44 |
| Integration & Control | 24 | Automated Material Handling | 5 |
| Automated Material Handling | 4 | Inspection | 13 |

Source: Statistics Canada. *Growth of Advanced Technology Use in Canadian Manufacturing during the 1990s*. December 1999.

Note: Methodological differences have been accounted for in this table.

trend, the continuing strong standing in Design and Engineering indicates that plants continue to focus on the knowledge-based component of manufacturing. Finally, strong standing in Network Communications appears to indicate increased sophistication in using technology at both the enterprise level as well as outside the enterprise – networking with partners and suppliers through supply-chain automation.

### Growth

The 1993 survey report indicates that growth in technology adoption in recent years had occurred mainly in the use of multiple technologies. The functional technology group with the highest rate of growth was Design and Engineering. Growth in the Design and Engineering sector was attributed to significant increases in the use of CAD and engineering technologies.

The 1993 projections indicated that further growth was projected to be highest in the Inspection and Communications technology group, with the second highest growth predicted for Integration and Control Equipment. By 1998, these predictions materialized. The Integration and Control Equipment category posted the second highest adoption rate at 49% and had a compounded annual growth rate of 46% over the five-year period for these technologies. The Inspection and Communications category was subdivided and the new Network Communications category did in fact post substantial growth and achieved the third highest average adoption rate overall at 47%.

Design and Engineering posted the highest average adoption rate at approximately 51% when weighted by establishment data. The average annual growth rate from 1993 to 1998 for this category was at 16%. This number is relatively low compared to the other categories; however, because this category started at a significantly higher level in 1993 than those of the other functional groups, it appears reasonable that the growth rate would be lower as it has less room to grow. The Automated Material Handling category posted high growth rates in 1998. However, this is due to a change in the technologies included in the 1998 definition. The addition of the use of part identification for manufacturing automation has inflated the growth figures.

Details of the adoption and growth rates by industry and functional group are presented in Table 29 which uses preadjusted data. In this table, the compounded industry growth rate indicates the rate of growth for the identified industry averaged for the technology groups that remained the same between the 1993 and 1998 surveys. This measure could be used as a proxy to gauge the technology adoption growth rate by industry.

### Adoption by Industry

In both the 1993 and 1998 survey reports, Baldwin, Sabourin and Beckstead made the point that the adoption of advanced technology varies considerably by industry. They noted that, for example, industries that tend to be dominated by larger establishments typically tend to have higher adoption rates. This results from the fact that larger organizations tend to have higher adoption levels than smaller ones. Establishments also have different adoption thresholds, different degrees of willingness to undergo the required changes, and different financial capabilities. In 1993, the leading industries that had adopted multiple technologies (10 or more) were Transportation Equipment, Petroleum and Chemicals, Primary Metals, Electrical and Electronic Products, and Non-metallic Mineral Products. The 1993 survey as well indicated that the five industries with the lowest level of adoption of advanced manufacturing technology were Printing, Publishing and Allied, Wood, Rubber and Plastics, Textiles and Clothing, and Food Processing.

By 1998, the industries with the highest adoption levels had changed significantly. The leaders became Beverage, Primary Textiles, Paper and Allied Products, Primary Metals, and Electrical and Electronic Products as shown in Table 30.

Over the five-year sampling time frame, only Primary Metals, and Electrical and Electronic Products managed to stay in the top five although they each dropped a level.

**Table 29: Comparison of Industries, Technology Adoption Rates by Functional Groups (percentage of establishments)**

| Industry | Design & Engineering | | | Fabrication & Assembly | | | Automated Material Handling | | | Integration & Control | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 93 | 98 | Growth | 93 | 98 | Growth | 93 | 98 | Growth | 93 | 98 | Growth |
| Electrical & Electronics | 66 | 79 | 3.6 | 27 | 59 | 17 | 4 | 27 | 47 | 8 | 72 | 55 |
| Primary Metal | 38 | 80 | 16 | 23 | 67 | 24 | 7 | 30 | 34 | 13 | 61 | 36 |
| Transportation Equipment | 37 | 66 | 12 | 28 | 55 | 15 | 3 | 40 | 68 | 8 | 58 | 49 |
| Paper & Allied | 39 | 55 | 7.1 | 13 | 63 | 37 | 8 | 41 | 39 | 16 | 66 | 33 |
| Petroleum & Chemicals | 22 | 39 | 12 | 13 | 40 | 25 | 4 | 19 | 37 | 19 | 54 | 23 |
| Other Manufacturing | 28 | 52 | 13 | 14 | 42 | 25 | 1 | 15 | 72 | 10 | 43 | 34 |
| Machinery | 43 | 70 | 10 | 28 | 60 | 17 | 4 | 19 | 37 | 5.8 | 60 | 60 |
| Non-metallic Minerals | 15 | 38 | 20 | 17 | 49 | 24 | 13 | 15 | 3 | 14 | 53 | 31 |
| Fabricated Metals | 25 | 71 | 23 | 24 | 56 | 19 | 0.4 | 10 | 90 | 6 | 54 | 55 |
| Rubber & Plastics | 21 | 50 | 19 | 12 | 66 | 41 | 5 | 23 | 36 | 8 | 55 | 47 |
| Textiles & Clothing | 14 | 31 | 17 | 8 | 30 | 30 | 1 | 18 | 78 | 5 | 43 | 53 |
| Furniture & Fixtures | 13 | 43 | 27 | 12 | 37 | 25 | 4 | 16 | 32 | 4 | 37 | 56 |
| Printing & Publishing | 21 | 36 | 11 | 11 | 30 | 22 | 0.4 | 16 | 109 | 5 | 45 | 55 |
| Wood | 10 | 37 | 30 | 11 | 53 | 37 | 3 | 18 | 43 | 5 | 43 | 54 |
| Average Adoption | 28 | 53 | | 17 | 50 | | 4 | 19 | | 9 | 53 | |
| Average Compounded Growth | | | 16 | | | 26 | | | 52 | | | 46 |

Sources: Baldwin, J. and Sabourin, D. *Survey of Innovation and Advanced Technology 1993: Technology Adoption in Canadian Manufacturing.* Statistics Canada, February 1995 – preadjusted numbers; Sabourin, D. and Beckstead, D. *Technology Adoption in Canadian Manufacturing: Survey of Advanced Technologies in Canadian Manufacturing.* Statistics Canada, August 1999 – preadjusted numbers.

**Table 30: A Comparison of Leading Industries of Technology Adoption**

| 1993 Leading Industries (Establishment Weighted) | 1998 Leading Industries (Establishment Weighted) |
|---|---|
| Transportation Equipment | Beverage |
| Petroleum & Chemicals | Primary Textiles |
| Primary Metals | Paper & Allied Products |
| Electrical & Electronic Products | Primary Metals |
| Non-metallic Mineral Products | Electrical & Electronic Products |

Sources:1993 and 1998 Statistics Canada Technology Adoption surveys – preadjusted numbers.

## Comparison of the Individual Technologies Adopted in 1993 and 1998

Table 31 may be used to provide a direct comparison of the leading technologies that were adopted in 1993 and 1998. The data appear to indicate that of the 10 leading technologies specified in 1993 and the eight specified in 1998, five are the same and still in the lead.

As indicated in Table 31, five technologies led in both 1993 and 1998. Paired technologies in order are as follows:

1. CAD/CAE
2. Programmable Controllers
3. Factory Computers
4. Technical LANs
5. Inter-company networks

**Table 31: 1993 and 1998 Functional Technologies Use by Industry (percentage of establishments)**

| 1993 Leading Technologies* | 1993 Leading Industries Adoption of 10 or More Technologies: Transport Equipment | Petroleum & Chemicals | Primary Metals | Electrical & Electronic | Non-metallic |
|---|---|---|---|---|---|
| CAD/CAE | 37 | 19 | 31 | 62 | 11 |
| Programmable Controllers | 20 | 24 | 23 | 21 | 17 |
| Factory Computers | 15 | 20 | 24 | 13 | 10 |
| Material Requirements Planning | 26 | 23 | 10 | 27 | 12 |
| Technical LANs | 9 | 17 | 12 | 26 | 7 |
| Factory LANs | 5 | 12 | 11 | 17 | 9 |
| Inspection of Final Products | 9 | 12 | 13 | 12 | 9 |
| Manufacturing Resource Planning | 14 | 14 | 9 | 15 | 4 |
| SCADA | 6 | 16 | 13 | 6 | 11 |
| Inter-company Networks | 11 | 6 | 15 | 10 | 6 |

| 1998 Leading Technologies** | 1998 Leading Industries: Beverage | Primary Textiles | Paper | Primary Metals | Electrical & Electronic |
|---|---|---|---|---|---|
| CAD/CAE | 34 | 37 | 46 | 68 | 75 |
| CAD/CAM | 32 | 38 | 36 | 40 | 46 |
| Programmable Controllers | 62 | 49 | 56 | 62 | 47 |
| LANs for Engineering or Production | 50 | 40 | 38 | 58 | 65 |
| Company-wide Computer Networks | 65 | 43 | 56 | 46 | 47 |
| Inter-company Computer Networks | 57 | 50 | 49 | 43 | 35 |
| Factory Floor Computers | 42 | 45 | 42 | 44 | 38 |
| Inspection Data for Control | 43 | 50 | 40 | 44 | 41 |

Sources: *Baldwin, J. and Sabourin, D. *Survey of Innovation and Advanced Technology 1993: Technology Adoption in Canadian Manufacturing.* Statistics Canada, February 1995 – preadjusted numbers; ** Sabourin, D. and Beckstead, D. *Technology Adoption in Canadian Manufacturing: Survey of Advanced Technologies in Canadian Manufacturing.* Statistics Canada, August 1999 – preadjusted numbers.

The 1993 survey defined CAD/CAE as "CAD is a computer-aided design [that] serves as an electronic drafting board allowing the user to easily produce, alter and store designs. CAE uses the computer to analyze and test product designs produced by CAD systems." By 1998, CAD/CAE was defined as the "use of computer-based software for designing and testing new products."

Programmable controllers were defined as programmable solid state units that are used as switching devices. In 1998, the definition remained the same. It is noteworthy that in both surveys this was the second highest technology being adopted.

Factory computers in 1993 were identified as computers used for control in factories. In 1998, these were defined as "computers used for control on the factory floor." Additionally, in 1998 these computers were defined as "stand-alone machines dedicated to controlling the manufacturing process, but are also capable of other functions." Computers used for this purpose were the third highest technology adopted in 1993, but by 1998 this technology had fallen to seventh on the list, perhaps illustrating the evolution from the use of stand-alone machines.

In 1993, Technical LANs were envisioned as being used to exchange information within design and engineering departments. As well, Factory LANs were seen as being used to exchange information on the shop floor. By 1998, these two technologies were captured in one technology group entitled LANs for Engineering or Production. The 1998 Statistics Canada definition for this grouping was "communication networks within a plant used for exchanging information on the shop floor and within design and engineering departments." This change may indicate a recognition of the use of these networks for technical work, irrespective of where this work is being done in the establishment.

Inter-company computer networks had the same definition in 1993 as 1998 – "WANS that connect establishments with their subcontractors, suppliers and customers." In 1993, in the leading industries, these networks had approximately a 10% adoption rate. By 1998 in the leading industries, this had grown to an almost 50% adoption level, thus supporting the current emphasis on supply-chain management issues.

The first four technologies taken together as a group over the 1993 to 1998 period tend to point to manufacturing automation that is internally focused. Enhanced integration of information appears to be supporting improvements in product quality and process, as well as increased efficiency in information that is exchanged throughout the manufacturing establishment. The last paired technology, inter-company computer networks, shifts the focus to outside the plant to the plant's markets and partners.

In 1993, Material Requirements Planning and Manufacturing Resource Planning were leading technologies being adopted. By 1998, these had been captured as Manufacturing Resource Planning, but had dropped in significance and were no longer on the leading list. As well, supervisory control and data acquisition (SCADA) technology which is used to perform real-time monitoring and controlling of production processes had lost its level of prominence by 1998.

CAD/CAM technology was defined in both 1993 and 1998 as the technology which uses the output produced by CAD systems to control the machines that manufacture the part or the product. It was identified as the third leading technology in 1998. A continued focus on the use of this technology may be the result of the increased integration that appears to be occurring in manufacturing facilities. Specifically, integrating this type of information may indicate a trend of lowering the "silos" between engineering and manufacturing, as well as an increased network sophistication capability.

### Technology Adoption by Region

An analysis of the adoption of technology by regions in Canada indicates that there are distinct differences in adoption patterns. Overall, Ontario tends to have the highest adoption levels in all categories: the adoption of multiple technologies, adoption of individual technologies, and adoption levels by functional group.

The Prairies and Quebec tend to trade second and third ranks among several categories. The Atlantic region typically follows the Prairies and Quebec, except in the adoption of individual technologies where it ranked third in both 1993 and 1998. British Columbia tends to place fourth or fifth when compared on a regional basis. Overall, however, the adoption figures by province tend to be quite close to the Canadian average.

This analysis examines how each of the regions ranks in terms of its adoption of technologies. The ranking system provides the ability to monitor changes in adoption trends. It is particularly useful when examining changes in the trends within the regions themselves, particularly as regions either increase or decrease adoption levels in specific technologies. It is also useful to provide provincial comparisons as this may reflect differences in industrial structure.

#### Technologies Used by Region

In the 1993 and 1998 Statistics Canada surveys mentioned previously, the Canadian regions identified were Atlantic, Quebec, Ontario, Prairies, and British Columbia. Technology adoption patterns broken down by these regions are shown in Table 32.

**Table 32: Numbers of Technologies Used by Region (percentage of establishments)**

| | Number of Technologies Used (percentage of establishments) | | | | | |
|---|---|---|---|---|---|---|
| | At least 1 | | Use of 5–9 Technologies | | Use of 10+ Technologies | |
| Region | 1993 | 1998 | 1993 | 1998 | 1993 | 1998 |
| Atlantic | 41 | 69 | 8 | 21 | 0.5 | 6 |
| Quebec | 36 | 70 | 10 | 24 | 1.5 | 9 |
| Ontario | 58 | 78 | 16 | 29 | 2.1 | 7 |
| Prairies | 44 | 72 | 9 | 24 | 0.4 | 8 |
| British Columbia | 40 | 68 | 5 | 18 | 0 | 5 |
| **Canada** | **47** | **74** | **12** | **26** | **1.5** | **7** |

Source: Industry Canada using Statistics Canada Data Tables, 2000.
Note: Methodological differences have been accounted for in this table; numbers have been rounded.

On the basis of ranking these three measures of technology adoption – at least 1, the use of 5 to 9 technologies and the use of 10+ technologies – all five regions have consistently increased their adoption levels of advanced technology. As well, each province achieved an adoption level that is quite close to the overall Canadian average.

In 1993, Ontario led in the overall adoption levels in all three categories. By 1998, Ontario maintained its lead in the use of at least 1 and in the use of 5 to 9 technologies but dropped to third place in the adoption of 10+ technologies; Quebec took the lead in this category.

In 1993, both Quebec and the Prairies ranked second for adoption levels in these three categories. Quebec placed second in the use of 5 to 9 and in the 10+ category, thus indicating relatively broad adoption levels. The Prairies placed second in the adoption of at least 1 technology and was in the middle range in the other two categories. By 1998, Quebec gained a small lead, maintaining its second place standing. It moved to first place in the 10+ category and remained second in the 5 to 9 category, again suggesting widespread adoption of multiple technologies. The Prairies, on the other hand, dropped to third place overall, even though it maintained its second place standing in the use of at least 1 technology and had jumped from fourth to second place in the use of 10+ technologies by 1998.

In 1993, Atlantic gained third place. In fact, it ranked third in both the use of at least 1 technology and 10+ technologies. It ranked fourth in the middle category. By 1998, Atlantic dropped to fourth and actually ranked fourth in each of the three categories.

Finally, British Columbia in both 1993 and 1998 had the lowest adoption levels in the mid- to high-range categories (i.e. the use of 5 to 9 technologies and in the 10+ grouping), and by 1998 it had the lowest adoption level in all three categories.

While it is interesting to look at how the different regions performed in technology adoption levels, the provincial measures were all very close to the Canadian overall total and the spread between the provinces while significant was not substantial.

### Functional Technology Use by Region

In the individual functional technology groups defined as Design and Engineering, Processing and Fabrication, Automated Handling Systems, Inspection, Network Communications, and Integration and Control, all regions significantly increased their adoption levels and again placed very close to the overall Canadian average adoption level, as shown in Table 33.

Ontario ranked first in every category in 1993. By 1998, Ontario continued to maintain its first place rank in

**Table 33: Functional Technology Use by Region**

| Region | Design & Engineering | | Process, Fabrication & Assembly | | Automated Material Handling | | Inspection | | Network Communications | | Integration & Control | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Functional Technology Groups (percentage of establishments) | | | | | | | | | | | |
| Year | 93 | 98 | 93 | 98 | 93 | 98 | 93 | 98 | 93 | 98 | 93 | 98 |
| Atlantic | 34.8 | 51.4 | 16.3 | 35.7 | 2.7 | 6.6 | 5.7 | 7.5 | 14.5 | 41.2 | 14.3 | 43.7 |
| Quebec | 27.6 | 45.8 | 18.4 | 43.8 | 3.7 | 4.4 | 6.3 | 10.9 | 15.5 | 40.5 | 18.3 | 50.8 |
| Ontario | 44.6 | 56.3 | 33.4 | 46.0 | 5.7 | 5.5 | 13.5 | 14.1 | 22.3 | 51.9 | 30.9 | 50.0 |
| Prairies | 35.8 | 49.8 | 15.6 | 40.1 | 2.2 | 7.8 | 9.1 | 14.8 | 14.3 | 51.4 | 21.5 | 44.7 |
| British Columbia | 28.3 | 44.9 | 16.3 | 42.1 | 0.5 | 4.0 | 5.5 | 7.4 | 12.1 | 37.8 | 16.0 | 39.7 |
| **Canada** | **36.6** | **51.4** | **24.4** | **44.1** | **4.0** | **5.3** | **9.9** | **12.7** | **18.0** | **46.9** | **23.9** | **48.5** |

Source: Industry Canada using Statistic Canada Data Tables, 2000.
Note: Methodological differences have been accounted for in this table.

Design and Engineering, Network Communications, and Processing and Fabrication. It dropped to second place in Integration and Control, as well as in Inspection Technologies by 1998. It fell to third in Automated Material Handling. It did, however, continue to maintain its overall rank in the adoption of the technologies contained in these functional groups.

In 1993, Quebec ranked second overall in the adoption of technologies by functional grouping. It ranked second in the adoption of Processing and Fabrication, Network Communications, and Automated Material Handling. It ranked third in the adoption of Integration and Control technologies, as well as in Inspection. It was fifth in its adoption of Design and Engineering. By 1998, Quebec dropped to a third place ranking overall. While it moved up to first place in the adoption of Integration and Control and up a level to fourth in the adoption of Design and Engineering, it maintained its same level in Inspection and Processing, and Fabrication as it had in 1993. It dropped from second place to fourth in both Network Communications, and Automated Material Handling by 1998.

While the Prairies ranked third in 1993, the region had moved into second place by 1998. The Prairies gained first place standing in the adoption of Inspection and moved from fourth to first in the adoption of Automated Handling Technologies. As well, it moved from fourth to second place in the adoption of Network Communications. However, it dropped from second in both Design and Engineering, and Integration and Control to third by 1998.

The Atlantic region maintained its fourth place standing in both 1993 and 1998. It moved up a ranking in three of these categories over this time period. For example, it went from third to second in Design and Engineering, third to second in Automated Material Handling, and fifth to fourth in the adoption of Integration and Control. It dropped from third to fifth place in the adoption of Processing technologies and maintained its 1993 standing in both Inspection and Network Communications.

British Columbia ranked fifth in both 1993 and 1998 in its adoption of advanced technology by functional grouping. It increased its standing from fourth to third in the adoption of Processing technologies during this five-year time frame. However, it dropped from fourth to fifth in the adoption of both Design and Engineering, and Integration and Control. Finally, it maintained its fifth place standing in the three remaining categories, Network Communications, Inspection, and Automated Material Handling.

### Regional Adoption of the 1998 Leading Technologies

The six leading technologies common to both the previously mentioned 1993 and 1998 Statistics Canada surveys were CAD/CAE, Programmable Logic Controllers, CAD/CAM, LANs for Technical Data and/or Factory Production, Computers Used for Control in Factories, and Inter-company Computer Networks.

When the provinces are ranked by their adoption of these six leading technologies between the 1993 and 1998 time frame, we see an interesting result. Ontario maintained its first place status in both 1993 and 1998, while the Prairies placed second. The Atlantic region placed third in both time frames. Quebec placed fourth in 1993, but moved to achieve third place with the Atlantic region in 1998. Finally, British Columbia ranked fourth in both 1993 and 1998. Again, however, all provinces showed a significant increase in the adoption levels of these six leading technologies over this five-year time frame.

As shown in Table 34, Ontario ranked first in the adoption of all these technologies in1993, except for CAD/CAM, where it ranked second. By 1998, Ontario ranked first in CAD/CAM, but dropped to second position in the adoption of LANs for technical data and factory use as well as second in the adoption of Inter-company Computer Networks.

In 1993, the Prairies placed second in the adoption of CAD/CAE, and Computers Used for Control in Factories. This region moved from fourth in 1993 to first in 1998 in the adoption of LANs for Technical Data and/or Factory production use. It also moved to first place in the adoption of Inter-company Computer Networks.

In the Atlantic region, a greater focus appeared to be the adoption of CAD/CAE technology and computers used for control in factories. CAD/CAE moved from third to second by 1998 and Computers Used for Control in Factories moved from fifth to third by 1998.

Quebec significantly changed its ranking during this five-year time frame in the adoption of three technologies. It moved from fifth spot to first in its adoption of CAD/CAM, from fourth to second in its adoption of Computers Used for Control in Factories, and from third to second in its adoption of Programmable Logic Controllers. It remained in third place in both time periods in its use of Inter-Company Computer Networks. Finally, it dropped a level in its use of CAD/CAE technologies and its adoption of LANs for Technical Data and/or Factory production.

In 1993, both British Columbia and Quebec ranked fourth in the adoption of these leading technologies. In 1998, British Columbia increased its adoption of CAD/CAE technology moving from fifth to fourth. It also increased its use of LANs for Technical Data and/or Factory production as it moved from fifth to fourth place. It dropped in its ranking in the adoption of Programmable Logic Controllers, Computers Used for Control in Factories, and Inter-company Computer Networks.

**Table 34: Leading Technologies in 1993 and 1998**

Leading Technologies (percentage of establishments)

| Region | CAD/CAE | | Program Logic Controllers | | CAD/CAM | | LANs for Tech. Data/Factory | | Computers for Factory Control | | Inter-company Computer Networks | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **93** | **98** | **93** | **98** | **93** | **98** | **93** | **98** | **93** | **98** | **93** | **98** |
| Atlantic | 28.9 | 48.0 | 10.3 | 32.0 | 20.4 | 33.4 | 13.1 | 30.5 | 9.6 | 27.4 | 3.6 | 25.2 |
| Quebec | 26.6 | 35.6 | 11.7 | 36.0 | 11.8 | 33.9 | 12.2 | 29.2 | 10.4 | 31.7 | 5.9 | 26.3 |
| Ontario | 38.4 | 50.3 | 25.0 | 39.0 | 19.4 | 41.0 | 16.9 | 40.1 | 21.6 | 32.4 | 12.8 | 31.5 |
| Prairies | 32.8 | 44.0 | 10.0 | 33.0 | 14.0 | 32.3 | 9.4 | 41.7 | 13.2 | 25.6 | 6.7 | 32.7 |
| British Columbia | 21.6 | 39.5 | 13.7 | 32.0 | 12.6 | 21.6 | 8.0 | 30.6 | 11.0 | 25.7 | 5.6 | 23.0 |
| **Canada** | **32.3** | **44.4** | **17.5** | **36.0** | **15.9** | **36.0** | **13.6** | **36.0** | **15.8** | **30.8** | **9.0** | **29.2** |

Source: Industry Canada using Statistic Canada Data Tables, 2000.
Note: Methodological differences have been accounted for in this table.

## Latest Advances in Technology

The results of the 1998 survey (Sabourin and Beckstead, 1999) indicated that few establishments are using some of the newer, emerging technologies such as rapid prototyping systems (5%), near net shaping technologies (7%), and digital, remote-controlled process plant control technologies (5%). These technologies were defined as follows:

| Technology | Definition |
|---|---|
| Rapid Prototyping | Systems capable of producing an output part from the output of a computer-aided design |
| Near Net Shaping | Technologies that produce finished plastic, metal or composite parts in a single production stage with a minimum of final machining |
| Digital Remote-Controlled Process Plant Control Technologies | LAN used to connect measurement and control equipment such as sensors and controllers |

The first two technologies may be particularly beneficial to manufacturers that produce in discrete industries as opposed to continuous manufacturing industries. Does identification of these types of technologies signal new and emerging trends – trends where technology adoption enhances specific manufacturing applications as opposed to technology adoption which enhances the enterprise as a whole? For example, it could be argued that between 1993 and 1998 technologies like CAD/CAM, factory floor computers and LANs could be seen to enhance the overall level of automation and sophistication in the complete manufacturing facility whether or not the facility was discrete or continuous. As this type of automation reaches a critical mass – enhancing the enterprise as a whole – will the focus of technology adoption then turn to adoption which specifically increases the competitive capability of a particular kind of manufacturing, as rapid prototyping would?

Identifying and classifying the past, current and emerging trends in technology adoption is critical to this study. Can it be established that technology adoption has occurred first in design and engineering, then on the shop floor, and now enterprise and supply-chain wide. If this is indeed the technology adoption trend, is a similar adoption evolution evident in the United States? If so, where is that country now headed, what emerging technologies is it using? What are its adoption rates of rapid prototyping and near net shaping? Answers to these questions would significantly strengthen this study.

## Canada and the United States

An examination of advanced technology adoption may be supplemented by comparing the available adoption information between Canada and the United States provided in the two Statistic Canada surveys, one conducted in 1993 (Baldwin and Sabourin, 1993), the other in 1998 (Sabourin and Beckstead, 1999), as well as data contained in *Benefits and Problems Associated with Technology Adoption in Canadian Manufacturing* (Baldwin, Sabourin and Rafiquzzaman, 1996). These sources provide data which incorporate a five-year time difference that indicates the evolution in adoption trends as well as changes in manufacturers' strategic direction. For example, in a comparison of how Canadian manufacturers rated their level of technology adoption between 1993 and 1998, manufacturers are indicating a less competitive position. In the 1993 survey, about 65% of Canadian manufacturers indicated they believed their production technologies were as good or better than their American counterparts. When asked the same question five years later, 57% of Canadian manufacturers indicated that their establishments were either equal to or more advanced than their American counterparts. These data raise the question as to why Canadian manufacturers perceive a significant decrease in their competitive position within a five-year time frame.

Baldwin and Sabourin (1998), in *Technology Adoption: A Comparison Between Canada and the United States*, compared a number of surveys – including the 1993 "Survey of Innovation and Advanced Technology" (Baldwin and Sabourin, 1993) and the "Survey of Manufacturing Technology" (Statistics Canada, 1991) conducted by Statistics Canada, as well as the 1993 "Survey of Manufacturing Technology" and the 1989 "Survey of Manufacturing Technology" conducted by the U.S. Bureau of Census – to access the adoption levels between Canada and the United States. The authors found that in five industrial sectors – Fabricated Metal Products, Industrial Machinery and Equipment, Electrical and Other Electronic Equipment, Transportation, and Instruments and Related Products – Canadian plant managers felt that they suffered a disadvantage. This perception was supported in the technological use data. However, the authors do indicate that between the 1989 and 1993 surveys, the technology gap between Canada and the United States had been halved, with 73% of Canadian plants and 81% of US plants using at least one technology. For example, the difference between adoption rates for a number of technologies in 1993 is shown in Table 35.

This table indicates that Canada led in one technology in the small-size category. In the medium-size category, Canada led in up to four technologies, which seem to be the break point. As well, Canada had a small lead in the large enterprise category with five or more technologies. Nine out of 10 large manufacturing establishments used at least five technologies regardless of country.

The authors indicated that, by 1993, the adoption pattern of advanced technologies between the two countries was very similar except in the communications technology group. Americans had widened the gap in new communications technologies, including LANs for Technical Data, LANs for Factory Use and Inter-company Computer Networks. Canadians between 1989 and 1993 narrowed the gap in older communications technologies, including Programmable Controllers and Factory Control Computers.

In 10 of the 17 technologies the authors compared, Canada had adoption rates similar to the United States. The seven technologies where Canada lagged in 1993 were CAD/CAE, N/C & CNC Machines, LANs for Technical Data, LANs for Factory Use, Inter-company Computer Networks, Programmable Controllers, and Factory Control Computers. Some of these technologies in particular appeared to comprise the group of core technologies that were adopted as indicated in the 1998 study.

| Where Canada Lagged in 1993 | Core Technologies Being Adopted in 1998 |
|---|---|
| CAD/CAE | CAD/CAE |
| NC & CNC | CAD/CAM |
| LANs for technical data | Programmable logic controllers |
| LANs for factory use | Local area networks |
| Inter-company computer networks | Company-wide computer networks |
| Programmable controllers | |
| Factory control computers | |

Sources: Baldwin, J. and Sabourin, D. *Technology Adoption: A Comparison Between Canada and the United States*. Statistics Canada, 1998; Baldwin, J. and Beckstead, D. *Technology Adoption in Canadian Manufacturing, 1998*. Statistics Canada, 1999.

Thus, the evidence appears to indicate that Canadian manufacturers are closing the gap between themselves and their US counterparts. In particular, they appear to be adopting technology in the areas where they were lagging five years before. The perception, however, of Canadian plants managers is that they are less technologically sophisticated (1993 @ 65% same as foreign counterparts and 1998 @ 57% same as foreign counterparts) which may have to do with a perception of trying to catch up to the Americans and not being able to close the gap as the United States pulls ahead.

### Diffusion Gap

The length of the diffusion lag can be used as a proxy to determine whether or not a country finds itself behind its major trading partners. The latest data available

**Table 35: Number of Technologies Used by Employment Size, 1993 (percentage of establishments)**

| Employment Size | Number of Technologies: 1 Technology | | 2 to 4 Technologies | | 5 or More Technologies | |
|---|---|---|---|---|---|---|
| | Canada (%) | US (%) | Canada (%) | US (%) | Canada (%) | US (%) |
| 20 to 99 | 23 | 17 | 33 | 38 | 14 | 20 |
| 100 to 499 | 5 | 7 | 47 | 34 | 33 | 53 |
| 500 or more | 0 | 2 | 5 | 10 | 89 | 86 |
| All sizes | 19 | 14 | 34 | 36 | 20 | 31 |

Source: Baldwin, J. and Sabourin, D. *Technology Adoption: A Comparison Between Canada and the United States*, 1998.

concerning the diffusion lag come from the 1993 study (Baldwin and Sabourin, 1995) which indicated that 79% of shipments are produced by establishments with a diffusion lag of less than five years. A significant portion comes from companies that adopt advanced technologies within one year. However, the largest share is found in the one- to three-year time frame. Interestingly, the diffusion lag between small and large plants is not significantly different. Obtaining data that indicate the current Canadian diffusion lag as well as the current diffusion gap between Canada and the United States would significantly strengthen this study.

## Benefits of Technology Adoption

Canadian manufacturers appear to be cognizant as well as confident in both understanding and identifying the benefits associated with technology adoption. The benefits associated with technology adoption as identified in the 1993 and the 1998 surveys are presented below. The results seem to indicate that the greatest benefits of adoption as perceived by manufacturers appeared in the productivity gains category in 1993. As of 1998, manufacturers identified both increased profitability and improved product quality as the leading benefits associated with technology adoption. This feedback may indicate an evolution in the benefits associated with the implementation of technology. Manufacturers seemed to be recognizing the gains made on the shop floor in productivity improvements in 1993. These appeared in 1998 to have translated into concrete benefits of improved product quality which is associated with the product improvement category, and increased profitability which is associated with improved market performance. Both tend to support improved market performance.

## Barriers to Adoption

In both the 1993 and 1998 surveys, the authors indicated that high equipment costs and cost of capital are the major impediments to advanced technology adoption. In 1993, high equipment costs were rated as important by 58.9% of respondents; in 1998 this had risen to 60%. The cost of capital in 1993 was rated as important by 48.9% of respondents, and this rose slightly in 1998, to 50%.

| 1993 Benefits of Technology Adoption | 1998 Benefits of Technology Adoption |
|---|---|
| Increases in productivity | Increased profitability |
| Reduction in labour requirements | Improved product quality |
| Reduction in material consumption rate | Reduced product rejection |
| Reduction in energy consumption | Increased production flexibility |
| Increased capital utilization rate | Increased equipment utilization |
| | Increased market share |
| | Reduced labour requirements |
| | Reduced set-up times |

| 1993 Intangible Benefits of Technology |
|---|
| Improved product quality |
| Increased skill requirement |
| Reduced product rejection rates |
| Reduced set-up times |
| Greater product flexibility |

Sources: Baldwin, J. and Sabourin, D. *Survey of Innovation and Advanced Technology 1993: Technology Adoption in Canadian Manufacturing*. Statistics Canada, February 1995 – preadjusted numbers; Sabourin, D. and Beckstead, D. *Technology Adoption in Canadian Manufacturing: Survey of Advanced Technologies in Canadian Manufacturing*. Statistics Canada, August 1999.

## Business Practices and Strategies

In the 1998 study, an exploration was conducted of various business practices and strategies for the first time. This study indicated that the strategic focus of manufacturing firms reported as most important were: cost reduction (53%), entering new markets and developing new products (30%), and strategies to promote new technologies (25%).

A point of clarification that could be raised in ongoing analysis would include understanding how current benefits, barriers and business strategies work in tandem in Canadian manufacturing companies. For example, the number one identified benefit is increased profitability when advanced technology is adopted. However, the number one barrier to adoption is the high cost of the equipment and the high costs required in order to achieve organizational integration. Given that the primary strategic focus of manufacturers is a strategy of cost reduction, one is left to wonder how Canadian manufacturers will continue to enjoy increased profitability if they are limited in their ability to increase further advanced technology adoption because of overall organizational cost-cutting measures.

## Connectedness in Manufacturing

### The Use of Communication Networks

A new section on Communication Networks was introduced into the 1998 *Technology Adoption in Canadian Manufacturing: Survey of Advanced Technologies in Canadian Manufacturing* (Sabourin and Beckstead, 1999). This study indicated that the use of communication networks, including the Intranet, Extranet and Internet, is expanding rapidly. Over 50% of all manufacturing plants are using at least one type of advanced network communications technology. Additionally, approximately one-third have adopted a LAN, and another third have adopted a company-wide computer network (including Intranet and WANs). Approximately 29% of manufacturing establishments have also acquired inter-company computer networks such as Extranets.

A similar study performed by the Manufacturing and Processing Technologies Branch of Industry Canada, entitled *Connectedness in Manufacturing: Survey of Standards Adoption in Canada* (1999), indicated that Canadian companies as a whole have experience with connectedness (electronic collaboration). Furthermore, the perception of survey respondents was found to be that successful implementation of collaboration standards had indeed brought benefits. The primary determinant of whether or not a company has previously been involved in electronic collaboration was the company's industry.

In this study, industry sector was identified as a more important determinant of prior electronic collaboration experience than either company size, organizational structure or head office. A company in either the Automotive (87%), Aerospace (91%), Electrical and Electronics (94%), or Industrial and Commercial Equipment (93%) sectors was more likely to have experience than a company in other industry sectors.

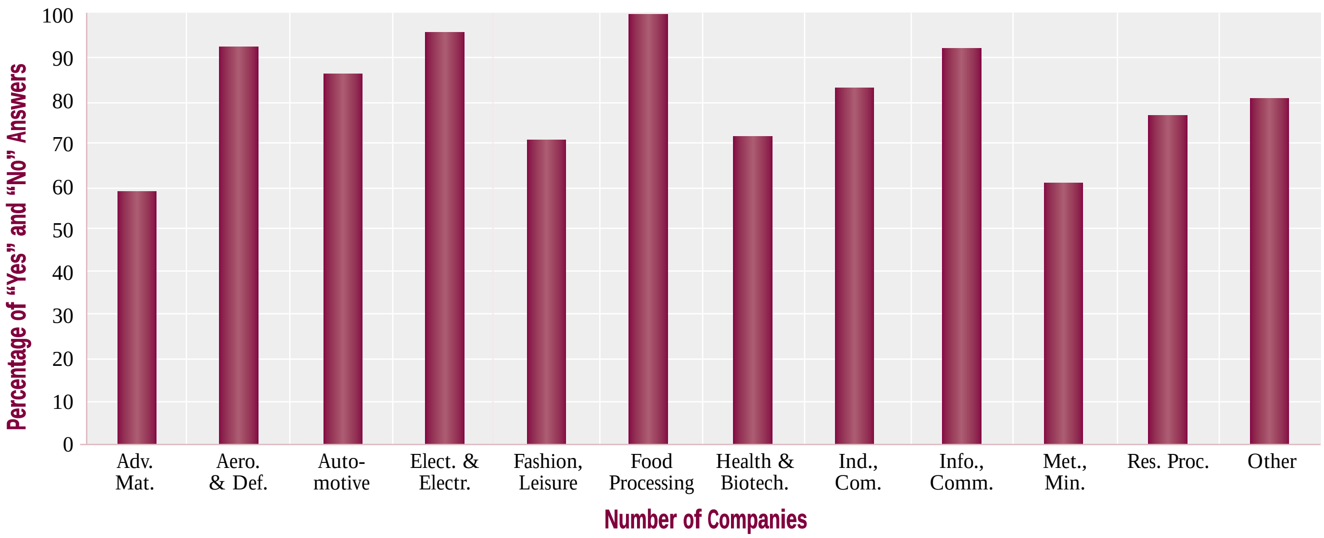
The study did not find any statistically significant difference across provinces or regions. While company revenue, number of employees, organizational structure and head office location were statistically significant factors in whether a firm had electronic collaboration experience, industry sector was the single most important predictor when these factors were considered together. In general, larger companies in terms of revenue and employees were more likely to have electronic collaboration experience. Also, firms with multiple sites and their head office outside Canada were more likely to have this experience.

The industry sector for the purposes of this report was broken down into three groups. The groups were identified as those most likely to have electronic collaboration experience to those least likely, as shown in Figure 10.

The first group included those industries that were most likely to collaborate electronically and posted approximately a 90% adoption level. Industries in this group were Food Processing, Aerospace and Defence, Automotive, Electrical and Electronics, Information and Communication Technologies, and Industrial and Commercial Equipment.

In the second group, the adoption level was approximately 75%. Industries included in this group were Resource Processing, Health and Biotech, and Fashion, Leisure and Household. The third group contained industries whose adoption levels were approximately 60%. These industries were Metals and Minerals Processing, and Advanced Materials and Plastics.

**Figure 10: Electronic Collaboration Experience by Industry Sector**




Source: Industry Canada. *Connectedness in Manufacturing: Survey of Standards Adoption in Canada*. 1999.

## Functional Use of Connectedness Technologies

The 1998 Statistics Canada study found that most establishments used their communication networks as a general reference tool. Results indicated that approximately 52% of establishments use these networks for this purpose. The next most popular uses for communication networks were for marketing and customer information applications and accounting and financing purposes – 46% of plants use it for each of these reasons. Tracking sales and inventory was fourth, followed by sharing information on technology.

Similarly, the Industry Canada study found the scope of adoption to be broadly based. Business transactions were exchanged by 67% of companies, engineering design by 80% and manufacturing by 54%. Thirty-seven percent of companies exchanged all three types of data. What was found surprising in the Industry Canada study was the perceived importance of performance benefits as opposed to market benefits. Companies appear to view standards as enabling efficient execution of their operational plans rather than developing new markets, through either new products or increased market share. Collaboration benefits were also regarded as more important than market benefits, but were not rated as highly as performance benefits.

Interestingly, a similar result was reported in a study conducted by IBM and the Department of Trade and Industry in the United Kingdom. In this study entitled *E-manufacturing – Harnessing the Power of the Web* (1999), it was reported that the Nordic countries appeared ahead of both the United States and the rest of Europe in recognizing and understanding the main drivers of electronic business applications. The Nordic countries cited increased efficiency as a main driver compared with visibility which dominated in the UK study. In Europe, the study reported that Germany has taken a longer-term view of the potential of electronic business collaboration and appears to be achieving greater implementation of the Internet across the supply chain. Approximately 94% of German companies recognized the long-term e-business needs and 33% were reported as implementing e-business solutions across multiple business processes.

## Innovation

According to Industry Canada's *Medium Term Policy Planning – Productivity* (1999), innovation was defined as value-added. It brings new products to market, develops new production processes and makes effective organizational changes. This report indicates that the Organisation for Economic Co-operation and Development (OECD) defines innovation in the following way: "Innovation allies curiosity-driven research with problem-solving and profit-driven applied R&D, thus creating and matching new technological and market opportunities."

In this document, research shows that innovative businesses tend to experience more growth than less innovative firms. As an illustration, differences in output growth are very apparent when firms are divided according to innovation intensity (high, medium and low). Over the period 1994 to 1997, the most innovative firms averaged growth of 4.7% per year. In comparison, the firms exhibiting the lowest levels of innovation experienced growth of only 2.3% per year.

According to *Innovation in Canadian Manufacturing Enterprises* (a second publication based on the results of the 1993 Statistics Canada survey) (Baldwin and Da Pont, 1996), Canadian firms were identified as being intensively involved in the innovation process. For example, 36% of all large Canadian firms either introduced an innovation over the period of 1989 to 1991 or were in the process of introducing an innovation in 1992–93. These innovative firms accounted for 42% of employment. In this study, Canadian firms were categorized as developing innovations as either world first, the first of its kind in Canada, or other.

The leading innovative industry in Canada at the time that this report was published in 1993 was Pharmaceuticals. This industry had over 74% of total industry employment in firms introducing either world- or Canadian-first innovations and over 85% of employment in firms producing any one of the three types of innovations – world first, Canadian first or other innovation (see Table 36).

As shown in Table 36, this study also indicated that Electrical and Electronic Products ranked second with 60% of employment in firms introducing firsts and 72% of employment in innovative firms. Textile Products, Primary Metals and Fabricated Products, and Chemical and Chemical Products followed at 52%, 44% and 42% for firms introducing firsts. Wood, Furniture and Fixtures, Food, and Printing and Publishing had the lowest innovation intensities with 8% to 12% of employment in companies introducing either world or

**Table 36: Innovation Intensity Across Industries (employment weighted)**

| Industry Class | World First (%) | Canadian First (%) | Other Innovations (%) |
|---|---|---|---|
| Pharmaceutical | 61.8 | 12.8 | 11.3 |
| Electrical & Electronic | 31.6 | 28.3 | 12.2 |
| Textiles | 24.5 | 27.1 | 8.3 |
| Primary Metals & Fabricated Products | 5.2 | 38.6 | 18.9 |
| Chemicals | 10.6 | 30.9 | 12.5 |
| Machinery | 2.7 | 24.1 | 22.7 |
| Rubber & Plastics | 15.1 | 8.5 | 34.2 |
| Paper & Allied | 7.8 | 15.5 | 25.7 |
| Other Manufacturing | 11.0 | 8.5 | 24.8 |
| Transportation Equipment | 10.3 | 4.8 | 25.6 |
| Wood, Furniture & Fixtures | 6.4 | 5.6 | 15.9 |
| Food, Beverage, Tobacco | 0.6 | 9.8 | 9.0 |
| Printing & Publishing | 1.9 | 6.2 | 39.3 |

Source: Baldwin, J. and Da Pont, M. *Innovation in Canadian Manufacturing Enterprises*. Statistics Canada, 1996.

Canadian firsts. When industries were ranked according to the amount of innovation introduced, regardless of the significance of the innovation, Rubber and Plastics, and Printing and Publishing moved up in ranking, while Textile Products moved down.

Overall, it was indicated that Canadian innovative firms tend to develop process innovations over product innovations. For example, 59% of innovations introduced represented process innovations compared to 42% that were product innovations. However, the study indicated that, overall, 62% of firms introduced a combined product/process innovation.

The benefits of incorporating innovativeness identified in *Innovation in Canadian Manufacturing Enterprises* (Baldwin and Da Pont, 1996) were enabling firms to gain increases in market share and profitability – 45% of world first increased their share of foreign markets. Other associated benefits identified were improved technological capabilities, improved product quality and extension of the product's range.

This study also indicated that innovative firms often increased their share of domestic and foreign markets as a result of introducing an innovation. The authors argued that the increase in market share may result from either the commercialization of product innovations that allow firms to change their output mix, or the introduction of process innovations. These, they believed, lead to more efficient production methods and thereby allow firms to aggressively compete for market share. The combination of these forces on the demand for labour was seen as positive. In fact, the report indicated that more than 40% of all world-first innovative firms indicated that they increased demand.

Baldwin and Da Pont (1996) indicated that the demand for labour in the white collar and blue collar groups was affected quite differently by innovation. Innovators increased demand for white collar workers more often than they decreased demand. This was found to be true both in the case of world-first and other innovators. However, the most common barrier cited by leading innovators was the lack of skilled labour. In fact, the survey results indicated that approximately 60% of world-first innovators and 40% of other innovators reported the lack of skilled labour to be a problem. The second most frequently mentioned problem by leading innovators was a lack of market information. A lack of information about prospective markets for new products was seen to create uncertainty, which reduced the inclination to invest in the innovation process.

The authors also indicated that research and development (R&D) efforts were the most important source of information used by world-first innovators. Approximately 86% of firms relied on this source to support innovation. In fact, it was indicated that this was the only source of internal ideas used by more than 37% of world-first innovators. While non-leading innovators were heavy users of R&D at 49%, they tended to rely more on management ideas. As well, ideas from production, sales and marketing staff were used by 32% of these firms.

Baldwin and Johnson, in *Business Strategies in Innovative and Non-Innovative Firms in Canada* (1995), provided additional analysis to the preliminary findings of the survey. In this study, the authors indicated that significant differences do exist between innovative and non-innovative firms. In addition to using the results of the 1993 survey, they conducted a follow-on survey directed at small- and medium-sized firms.

Additional findings included:

1. Innovative firms place greater emphasis on the importance of labour skills. As a result, they place more emphasis on training. Both formal and informal training is a focus; innovative firms train a higher percentage of their employees and spend a higher amount on training per employee.
2. Financing has a greater emphasis in innovative firms. Growth is more closely tied to the cost of capital and access to capital. Funding sources focus on venture capital, public equity, and parent companies.
3. Innovative firms focus on marketing. They provide higher-quality products and more customer service. Their product lines are more flexible; thus, they tend to introduce new products more often and are more in tune with customer needs.
4. Innovative firms stress cost reduction and are more likely to make capital investments. They place more focus on production economics.
5. Innovative firms are aware of and use government programs. They make greater use of export incentives, industrial support, government procurement, training programs, and R&D tax incentives.

**Table 37: Innovative Strategies and Activities in Manufacturing**

| Innovative Strategies and Activities* | | |
|---|---|---|
| **Strategies** | **Innovative** | **Non-innovative** |
| Ability to adopt technology as a factor in growth | 3.2 | 1.9 |
| R&D innovation capability as a factor in growth | 2.3 | 0.4 |
| R&D spending relative to competitors | 2.3 | 0.7 |
| Importance of R&D tax incentives | 1.7 | 0.4 |
| Developing new technology | 3.1 | 0.9 |
| Refining other's technology | 2.8 | 1.2 |
| Improving own technology | 3.6 | 2.2 |
| Reducing energy costs | 3.1 | 2.3 |
| Using existing materials more efficiently | 3.4 | 1.8 |
| Using new materials | 2.9 | 1.1 |
| Employing just-in-time inventory control | 3.0 | 1.9 |
| Employing process control | 3.2 | 1.2 |
| R&D unit as a source of innovation | 1.9 | 0.2 |
| Canadian patents as a source of innovation | 1.0 | 0.3 |
| Foreign patents as a source of innovation | 1.0 | 0.3 |
| Aggregate score of typically non-innovative sources of innovation | 21.5 | 15.3 |
| **Activities**** | | |
| Investment in R&D for new products | 18.9 | 3.2 |
| Investment in R&D for new process | 5.7 | 0.3 |
| Percent of employees in the R&D unit | 2.6 | 0.1 |

Source: Baldwin, J. and Johnson, J. *Business Strategies in Innovative and Non-innovative Firms in Canada*. Statistics Canada, 1995.
*Average score on a scale of 0 to 5. **Percents.

6. Innovative firms stress the importance of management and management strategies. They tend to focus on management training, new and evolving organizational structures, and total quality management.
7. Innovative firms are more successful, they grow faster, they achieve greater market share and increased growth in profits.

From a strategic perspective, differences between innovative and non-innovative firms are highlighted in Table 37. All the results presented are very significant (at the 1% level) and thus indicate substantial differences between the two groups.

Although Statistics Canada indicated that Canada is actively involved in the innovation process, Industry Canada's medium-term policy document indicated that Canada has an innovation gap and this is one of the major causes of our poor productivity performance. We invest in less R&D and are slower to adopt new technologies and processes (including information technologies) even though our R&D tax incentives are much more generous than the United States.

According to the Conference Board of Canada, Canada is by far the most reliant of the G-7 economies on foreign technological inputs (over two-thirds are sourced outside Canada). Canada is willing to utilize knowledge-intensive inputs but lacks the domestic capacity to develop more of its own. Canadians are less inventive. At best we are little more than half as inventive as our US counterparts (Industry Canada, *Medium Term Policy Planning – Productivity*, 1999).

## Human Capital Issues in Manufacturing

*Medium Term Policy Planning – Productivity* (Industry Canada, 1999) indicated that there is an increasing need for skilled labour in Canada. This need is present in all levels of the economy, from knowledge workers to moderately educated and semi-skilled workers. It also indicated that labour markets must be capable of adjusting in response to the needs of industry. This situation is especially prevalent in the manufacturing industry which is experiencing significant skill shortages in professional, skilled trades, and technologist categories.

Baldwin, Gray and Johnson (1995) indicated that the requirement for skilled labour has been increasing significantly since the 1980s. Manufacturing enterprises are integrating labour-saving and labour-enhancing technologies which represent "soft manufacturing." This trend toward soft manufacturing differs from traditional manufacturing; software and computers are becoming as important a part of the manufacturing process as production machines. As firms embrace these soft manufacturing techniques, they are able to tailor their products to individual buyer's needs, respond quickly to individualized orders, and achieve economies of scale. Technology adoption increases the demand for workers with greater conceptual and problem-solving skills.

Additionally, they found that the importance of advanced technologies and skill upgrading is much greater for large plants than for small. Large plants are more likely to use advanced technologies and to combine these technologies from different functional categories as they move to develop integrated factories. As they adopt advanced technologies, they more often find that their skill requirements increase. This finding is further supported in the results of the survey on technology adoption in Canadian manufacturing (Sabourin and Beckstead, 1999).

This report indicated that approximately two thirds of technology users have experienced a shortage of skilled personnel during the past year. Two occupational categories predominate in skill shortages: professional and skilled trades. In the professional category, industrial and manufacturing engineers, and electrical engineers are identified as dominating the category at 25% and 19% respectively. In the skilled trades category, the critical shortages were for machine operators (27%) and machinists (24%). In the technician and technologist category, the highest shortages were in CAD technicians, computer programmers, and electronic and computer hardware specialists. Finally, in the management category, production managers and design managers were the occupations with the highest shortage. An analysis of the findings by occupation group is presented in Table 38.

In recognition of the difficulties associated with skill shortages, three quarters of the technology users who responded to this survey indicated that they had provided training to their staff regarding the adoption of advanced technologies in the past three years. This training focused predominately on computer and technical skills. Further, nine of every 10 establishments provided training geared to improving technical skills and approximately 50% of establishments had also provided computer training. In addition to training, a number of other initiatives were undertaken, which are indicated in Table 39.

Finally, the *Feasibility Study of an Advanced Manufacturing Technology Human Resource Strategy* (ARA Consulting Group Inc. and John O'Grady Consulting Ltd., 1998) indicated that skill shortages in manufacturing are sufficiently strong to proceed with recommendations for immediate action. Recommendations arise from feedback from industry interviews and revolve around skill shortages associated with the advanced manufacturing technology industry. They are as follows:

- Universities and community colleges should be more flexible and "in tune" with industry needs, better funded and better equipped.
- Cross training, project management and other soft skills should be emphasized.
- There should be more cooperation among institutions and more partnerships between industry and local postsecondary institutions.
- English-language, communications and computer literacy skills are essential.

**Table 38: Skilled Personnel Shortage (percentage of establishments)**

| Occupation | Yes | No | N/A |
|---|---|---|---|
| **All Occupations** | **66% of establishments** | | |
| **Professionals with University Degrees** | **41% of establishments** | | |
| a) Mechanical/Aerospace | 13 | 51 | 36 |
| b) Electronic/Computer | 19 | 55 | 26 |
| c) Chemical/Chemical Process | 4 | 56 | 39 |
| d) Industrial/Manufacturing Process | 25 | 52 | 23 |
| e) Science Professionals | 3 | 58 | 39 |
| f) Computer Scientists | 8 | 57 | 35 |
| **Management** | **31** | | |
| g) Production Management | 21 | 71 | 8 |
| h) Design Management | 17 | 69 | 14 |
| i) Human Resource Management | 8 | 79 | 13 |
| **Technicians and Technologists** | **37** | | |
| j) Electronics/Computer Hardware | 15 | 63 | 22 |
| k) Science Technicians | 3 | 62 | 36 |
| l) Engineering Science Technicians | 10 | 59 | 31 |
| m) Computer Programmers | 16 | 62 | 22 |
| n) Communication Network Administrators | 10 | 67 | 23 |
| o) Computer-Aided Design | 18 | 64 | 19 |
| p) Instrumentation | 6 | 67 | 28 |
| **Skilled Trades** | **40** | | |
| q) Machinist (including tool, die mould) | 24 | 58 | 18 |
| r) Machine Operator | 27 | 61 | 12 |
| s) Electrical Equipment Operator | 7 | 69 | 24 |
| t) Process Plant Operator | 11 | 68 | 21 |
| **Other** | **7** | **22** | **72** |

Source: Sabourin, D. and Beckstead, D. *Technology Adoption in Canadian Manufacturing*. Statistics Canada, 1999.

- Training institutions should look outside Canada's borders for more effective education and training models.
- Labour market monitoring is required.
- Technology education in elementary school should be introduced.
- In-house industry training should be increased.

**Table 39: Steps Taken to Deal with the Skill Shortages (percentage of establishments)**

| Steps | Yes | No | N/A |
|---|---|---|---|
| a) Provided Training | 84 | 16 | 1 |
| b) Improved Wages and Benefits | 64 | 32 | 4 |
| c) Established Stronger Links with Educational Institutions | 50 | 45 | 5 |
| d) Searched for Skilled Personnel | 93 | 6 | 0 |
| e) Other | 5 | 33 | 62 |

Source: Sabourin, D. and Beckstead, D. *Technology Adoption in Canadian Manufacturing.* Statistics Canada, 1999.

## Concluding Remarks

On the basis of the aforementioned analyses, we may conclude that the historic performance of Canada's manufacturing sector over the period 1983 to 1997 has been quite strong. Manufacturing has grown faster than the rest of the economy. From 1983 to 1997, GDP in manufacturing grew by 3.5% per year, compared to 2.7% for the economy as a whole.

Manufacturing's contribution to GDP has increased. In 1983, GDP in manufacturing accounted for 16% of the total GDP. This production share increased to 18% by 1997, more than any other sector.

Labour productivity measured in real value of shipments per person-hour paid has accelerated 1.7% annually between 1983 and 1997. It grew about 2.2% per year over the same period when labour productivity was measured in real value-added. Most of the 22 industrial groups in the manufacturing sector have experienced strong growth of labour productivity, with minor exceptions of a few industrial groups, such as Printing, Publishing and Allied, Fabricated Metal Products, Plastic Products, Food, Leather and Allied Products, and Wood.

For the manufacturing sector as a whole, Quebec appeared to have the fastest growth rate of labour productivity with 2.1% for the period 1983 to 1997, followed by Ontario with 1.9%, Atlantic with 1.7%, British Columbia with 0.7%, and Prairies with only 0.2%.

In terms of sectoral comparison, the Agricultural sector had the fastest labour productivity per person growth rate with 3.2% over the period 1983 to 1997, followed by Transportation, Storage and Communication with 2.7%, Manufacturing with 2.5%, Trade with 2.2%, Finance and Real Estate with 1.3%, Utilities with 0.9%, Other Primary Industries with –0.8%, and Construction with –1.3%. The labour productivity per person for the national economy was 1.1% for the same period.

Based on OECD statistics, it is estimated that Canada's labour productivity per hour, adjusted by the purchasing power parity index, was equivalent to 65% of the US counterpart in 1983, and the equivalent level was reduced further to 59% by 1996.

By using OECD statistics, it is estimated that the growth rate of labour productivity, measured by shipment per person adjusted for purchasing power parity, was 5.7% for Japan, 4.1% for the United States, 3.1% for Canada, 2.5% for France, and 0.9% for Italy between 1983 and 1996.

To cope with the FTA, NAFTA, and industrial globalization over the period 1983 to 1997, manufacturing in Canada adopted the strategies of increased exports and the rationalization of industries. Production costs have been gradually reduced by either the reduction of employment and/or decreased wages.

Manufacturing has contributed technological advances through investment in R&D and new process technologies. Manufacturing is the second largest investor in the economy, next only to the housing industry. In 1997, manufacturing invested $19 billion or 12% of the total investment in the Canadian economy.

The leading manufacturing industries of technology adoption in 1993 were Transportation Equipment, Petroleum and Chemical, Primary Metal, Electrical and Electronic Products, and Non-metallic Mineral Products; however, the leading industries based on the 1998 survey results became Beverage, Primary Textile, Paper and Allied Products, Primary Metal, and Electrical and Electronic Products.

Among the 21 advanced technologies adopted by industry, five technologies led in both the 1993 and 1998 surveys: Computer Aided Design/Engineering, Programmable Controllers, Factory Computers, Technical LANs, and Inter-company Networks. For barriers to technology adoption, both 1993 and 1998 surveys consistently indicated that high equipment costs and the cost of capital are the two major impediments.

The following issues are being faced by Canada's manufacturing sector:

### Technology Adoption and Productivity

The study did confirm that those industries leading in technology adoption in the manufacturing sector would experience an acceleration of their labour productivity. For instance, the leading industries of technology adoption in the 1998 survey were Beverage, Primary Textile, Paper and Allied Products, Primary Metal, and Electrical and Electronic Products. These five industrial groups were also the leading industries of labour productivity growth measured either in real value of shipments or value-added per person hour paid. This result raises a policy issue: how can the federal government influence less competitive industries to adopt more advanced technologies in order to increase productivity and competitiveness?

### Investment and Productivity

Another source of productivity growth is investment in physical capital, specifically factories and equipment. As a result of the speed-up in investment, the stock of useful machinery is much larger and more productive capacity has been created. This study shows that most of the industries in the manufacturing sector with a relatively high growth rate of the capital:labour ratio have a corresponding high productivity growth rate. This implies that sustaining stronger productivity growth will require stronger investment. The question is: how do federal and provincial/territorial governments promote investment in the economy in general? And in the manufacturing sector in particular?

### Technology Adoption Trends and Direction

Identifying and classifying the past, current and emerging trends in technology adoption is critical to this study. Can it be established that technology adoption has occurred first in design and engineering, then on the shop floor, and now enterprise and supply-chain wide? If this is indeed the technology adoption trend, is a similar adoption evolution evident in the United States? If so, where is that country now headed, what emerging technologies is it using? What is its adoption rates of rapid prototyping and near net shaping? Is manufacturing automation evolving from the generic – plant and industry wide – to specific applications tailored to specific industries?

### The Diffusion Gap and Benchmarking Against the United States

The latest data available concerning the diffusion lag come from the 1993 study which indicated that 79% of shipments are produced by establishments with a diffusion lag of less than five years. A significant portion comes from companies that adopt advanced technologies within one year. However, the largest share is found in the one- to three-year time frame. Obtaining data that indicate the current Canadian diffusion lag as well as the current diffusion gap between Canada and the United States may provide a useful vehicle to illustrate the way ahead to Canadian manufacturers.

It appears that the Americans intend to invest heavily in technology as their means to continue to increase their productivity. Is this trend influencing Canadian manufacturers' perception of their inability to catch up to the Americans' level of technology adoption, particularly if they believe the intensity of adoption is increasing significantly, thus increasing the distance of the gap?

### Will Current Manufacturing Strategies Support Continued Growth?

A point of clarification that could be raised in ongoing analysis would include understanding how current benefits, barriers and business strategies work in tandem in Canadian manufacturing companies. For example, the number one identified benefit is increased profitability when advanced technology is adopted. However, the number one barrier to adoption is the high cost of the equipment and the high costs required in order to achieve organizational integration. Given that the primary strategic focus of manufacturers is a strategy of cost reduction, how can Canadian manufacturers continue to enjoy increased profitability if they are hindered for further advanced technology adoption because of overall organizational cost-cutting measures?

### Connectedness Comparison Studies from the United States and Europe

As indicated in the report, similar results and benefits of implementing connectedness initiatives are being identified in numerous countries. Follow-on analysis of uses and benefits of collaboration efforts in manufacturing communities globally would provide useful feedback to this audience.

### Reduction of Production Costs Through Materials and Supplies Component

The use of labour has clearly been rationalized and the capital:labour ratio has improved for many industries with strong labour productivity growth. The reduction in the wages and salaries component has been the most significant area of cost reductions overall. Materials and supplies, on the other hand, are also an important cost component, but it has not seemed to have been the target of cost reductions as has the labour component. Thus, there may exist an important potential to reduce costs through superior use of physical inputs that should be explored.

### Innovation and Productivity

Innovation plays a key role in productivity growth. Although some of Canada's industries, such as Pharmaceutical, Electrical and Electronic Products, Textiles, Primary Metal, and Chemical and Chemical Products are quite innovative, most of the manufacturing industries are less inventive compared with their US counterparts. According to *The Global Competitiveness Report* (World Economic Forum, 1998), Canada ranks 18th in total expenditure on R&D per capita in the world. Among G-7 countries, we are only slightly ahead of Italy and we fall far behind Japan, the United States, Germany, France, and United Kingdom. The innovation gap in Canada is also reflected by the fact this country issued fewer patents in the past year than G-7 countries. In terms of patents granted to residents in 1995–96, Canada ranked 19th in the world, far behind all other advanced economies. The following issue becomes apparent: how can the federal government encourage the Canadian corporate and public sectors to undertake more R&D and major companies to spend more on innovative equipment and machinery, thus increasing both their productivity and their innovativeness?

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# Appendix 1

## Total Factor Productivity

From an economic theoretical viewpoint, total factor productivity (TFP) is a better concept to be used; however, there are some measurement problems associated with TFP. These include:

1. TFP growth is calculated as the difference between growth in output produced and the growth of all inputs such as labour and capital stock (i.e. output gains that cannot be explained by increased inputs). This implies that TFP is a residual which can result from technological change, economies of scale, and changes in the organization of production.
2. There are serious difficulties associated with the measurement of the capital stock, especially in the treatment of depreciation. To calculate physical stock depreciation, the use of geometric depreciation, straight line depreciation and delayed depreciation will produce substantial difference in the capital stock, and little agreement among economists on the best procedures to follow.
3. No international comparison of TFP is possible due to difficulties of TFP measurement.

# Appendix 2

## Summary of Labour Productivity by Size of Industrial Group

Eighteen of the 22 industries for which there are sufficient data have been summarized below.

**Food:** This industry seemed to contradict the expected relationship with medium-sized establishments having the highest productivity levels and large the lowest. In terms of growth rate, small establishments became the most productive while large remained with the lowest levels.

**Beverage:** Data were available only for large establishments which exhibited growth of 4.9%, consistent with the relatively high productivity estimate for the industry as a whole.

**Rubber:** In 1997, the large establishments group had the highest levels followed by medium and small, but medium grew slightly faster than large and small groups over the period 1984 to 1997.

**Plastic:** Data were available only for the small group which had registered a negative growth at an average annual rate of -0.3% over this period.

**Primary Textiles:** Data were also available only for the small establishments group, but its labour productivity grew 2.8% annually.

**Textile Products:** Labour productivity levels appeared to be consistent with employment size. However, the medium-sized establishments experienced a negative growth rate of 0.4% over the same period.

**Clothing:** Small establishments were the most productive followed by large. While all experienced positive growth, the small establishments group outpaced both medium and large.

**Wood:** The medium category had the highest levels and small the lowest, but the small establishments group had productivity growth of -0.1% per year.

**Furniture and Fixtures:** Data were available only for the small category. The results revealed declining productivity at a rate of 0.3% per year during the period 1984 to 1997.

**Paper and Allied:** There was a clear positive relationship between size class and productivity in both cases of growth and levels.

**Printing, Publishing and Allied:** Data were available only for the small class which had an average annual growth rate of -0.1% between 1984 and 1997.

**Primary Metal:** This group exhibited a positive relationship between employment size and labour productivity levels, except in 1984 when medium outperformed large. However, the small group had the highest productivity growth rate.

**Fabricated Metal:** Labour productivity levels tended to have a positive relationship with employment size, with similarity between medium and large. The same is true in growth rates.

**Machinery:** This industry had a clear positive relationship between size and productivity. Productivity grew 2.1%, 1.3%, and 0.3% respectively for large, medium, and small.

**Transportation Equipment:** The large establishments group had by far the most productivity. Similarly, the large establishments' growth was more than twice that of medium and almost three times that of small establishments.

**Electrical and Electronics:** This industry also had a strong positive relationship between levels and growth to size. Productivity growth rates for the large category were 7.4%, vs. 3.5% for medium, and 2.4% for the small establishments.

**Non-metallic Minerals:** It seemed that medium-size establishments performed much better than the large and small establishments in both labour productivity levels and growth rates.

**Refined Petroleum and Coal:** Data were available only for the large establishments group which grew at an average annual rate of 2.7%.

# Appendix 3

## Total Costs to Shipments Ratio by Industrial Group

The following five industries had the lowest total costs to shipments ratio in 1997, at 59%, 63%, 68%, 68%, and 70% respectively:

**Beverage:** In terms of cost breakdown, this industry's lower supplies to shipments costs largely accounted for its lower total costs to shipments ratio, 44.2% versus 61.4% for the entire sector, up from 43.6% in 1983. The wages and salaries and energy and fuel components declined relative to shipments, falling from 18.2% to 13.7%, and from 2.1% to 1.1% respectively, with wages and salaries responsible for most of the decline in total costs to shipments. Due to the differences in the cost components growth rates, wages and salaries, and energy and fuel both declined as a share of costs while materials and supplies rose to 75% from 68% in 1983.

**Tobacco Products:** This industry had the second lowest ratio of total costs to shipments having dropped from 68% to 63% by 1997. In 1983, tobacco also had a lower supplies component at 52.8% in contrast to 61.9% for the entire sector. The wages and salaries, energy and fuel, and materials and supplies components' ratios to shipments of 22%, 1%, and 77% were also in line with the sector's 21%, 3%, and 76%. By 1997, costs versus shipments had fallen while the composition of costs also changed to a significant extent. From 1983 to 1997, shipments grew at an average annual rate of 7.6% while wages and employment levels grew at 1.1% and -4.6% per year. As a result, the wages to shipments ratio fell from 15% to 6.5%, energy and fuel fell from 0.7% to 0.2%, and materials and supplies increased to 56.3% from 52.8%.

**Chemical and Chemical Products:** This industry experienced the largest percentage point drop in the total costs to shipments ratio, falling eight percentage points. This decline was actually due to a combination of declines in all three components. As a share of shipments, wages and salaries, energy and fuel, and materials and supplies fell from 13.2% to 10.8%, 6.3% to 3.4%, and 56.3% to 53.8% with shares of total costs going from 17% to 16%, 8% to 5%, and 74% to 79% respectively.

**Printing, Publishing and Allied:** Total costs to shipments fell only slightly during this period, down 2 percentage points to 68% with little change in component shares. What is most interesting is the relative ratios of the components. Wages and salaries make up an unusually large share of total costs in this industrial group. In 1983, this component had a ratio of 31.9% and 29.8% in 1997 in contrast to 17.1% and 14.3% for the manufacturing sector as a whole. Energy and fuel remained at 0.8% and supplies remained stable at 37.7% in 1997, relatively low when compared to the total manufacturing sector's supply costs of 79%.

**Non-metallic Minerals:** This group is characterized by relatively more important wage and salary, and energy and fuel components, although total costs to shipments did fall to 70% from 75%. The ratio of wages and salaries, energy and fuel, and materials and supplies to shipments was 23%, 9%, and 42.6% in 1983 and 19.4%, 5.9%, and 44.5% in 1997. As with the manufacturing sector as a whole, this group's wages and salaries, and energy and fuel cost decreased in importance while that of materials and supplies increased slightly.

The following industries experienced a drop in the ratio of total costs to shipments greater than the total manufacturing ratio:

**Rubber:** Total costs to shipments fell 1% to 80% with virtually all of the downward movement in costs due to a drop in the wages and salaries component. In 1983, wages and salaries was at 21.9% of shipments, above that for total manufacturing, but had fallen below it by 1997, reaching 13.2%. Energy and fuel cost shares also fell, going from 2.3% to 1.1%, while materials and supplies rose significantly. With materials and supplies increasing at a rate of 9.4% per year and shipments at only 8.2% per year, the ratio of materials and supplies costs to shipments went from 56.7% to 65.6%, above the manufacturing sector's ratio as opposed to below it in 1983. By 1997, wages and salaries, energy and fuel, and materials and supplies accounted for 17%, 1%, and 82% of total costs.

**Wood:** Total costs had reached a ratio of 85% to shipments in 1983 but had fallen to 81% in 1997. Here too a more significant wage component was largely responsible, although the ratio to shipments did experience a significant decline going from 25% to 17% by 1997; however, this is still higher than 14.3% for the entire manufacturing sector. The energy and fuel component was in line with the sector ratio and fell from 3.3% to 2.2% of shipment values. Supply costs began the period at 57% and reached 61.5% in 1997, moving from 4.9 percentage points below the sector ratio to essentially matching it. As shares of total costs, wages and salaries, energy and fuel, and materials and supplies moved to 21%, 3%, and 76% from 29%, 4%, and 67%.

**Leather and Allied Products:** With total costs to shipments at 81% in 1983, this was one of only two industries with an increase in total costs to shipments, moving up to 82%. Both shipments and costs fell, but shipments decreased by 1.1% per year versus 1.0% for costs. The energy and fuel component remained stable at around 1% of shipments. The wages and salaries component fell from 26.9% to 23.6% of shipments and to 29% of total costs, but still remained significantly above the manufacturing sector's ratios. The materials and supplies component remained below that of the sector with respect to shipments but rose from 53.3% to 57.8% by 1997.

**Transportation Equipment:** This industrial group owes its higher costs to shipments ratio to the supply component, while the decrease from a level of 85% to 83% of shipments was due mostly to a drop in the wages and salaries component. Materials and supplies had a ratio of 73.3% in 1997, little changed from 72.3% in 1983. Wages and salaries, on the other hand, were at only 11% of total costs and 9.4% of total costs in 1997, down from 14% and 12% respectively in 1983. Energy and fuel was the smallest component at 0.5% with respect to shipments, down from 0.8%.

**Refined Petroleum and Coal Products:** This industry not only had the highest ratio of costs to shipments, it also experienced the largest percentage point increase, up two percentage points reaching 93%. In fact, all three cost components increased relative to shipments. As a ratio of costs to shipments, materials and supplies represented a very large share at 87% in 1983, wages and salaries at 3.1%, and energy and fuel at 1.2%. By 1997, the materials and supplies ratio had reached 88%, wages and salaries 3.8%, and energy and fuel 1.6%.

The following industries also experienced large decreases in total costs relative to shipments:

**Primary Textile:** Total costs to shipments fell from 81% to 74% over the period, largely due to the decline in the wages and salaries component which fell from 20.5% in 1983 to 16.2% in 1997. The energy and fuel, and materials and supplies components also fell from 3.5% to 2.5% and from 57.3% to 55.0% respectively.

**Textile Products:** Total costs to shipments fell slightly from 78% to 77% over the period. Wages and salaries as a share of shipments was constant while both energy and fuel, and materials and supplies costs fell relative to shipments.

**Paper and Allied Products:** The wages and salaries, and energy and fuel components for this industry were larger than for the manufacturing sector as a whole, moving from 21.2% to 15.9%, and 10.1% to 8.0% of shipments respectively. Material and supplies remained close to 52% over this period. As a result of these movements, total costs to shipments fell from 83% to 76% over this period.

**Other Manufacturing:** The decline in the ratio of total costs to shipments for this industry was largely due to the changes in the materials and supplies cost component even though its share was relatively smaller than in other industries. This component began at 52.0% of shipments and ended at 46.5%. The wages and salaries component was also relatively large at 23.1% in 1997, down only slightly from 24.4% in 1983.

The following eight industries have experienced significant relative cost component movements, which may identify important trends or characteristics.

**Electrical and Electronic Products:** This group has experienced significant changes in cost components which were more dramatic than the two percentage point drop of total costs to shipments, down to 75% from 77% in 1983. Although the materials and supplies component remained smaller than for manufacturing as a sector, it is still the largest single component and grew from 50.9% to 58.7% of shipments. The wages and salaries component has been declining quickly and is close to matching the sector's ratio, decreasing from 25% of shipments to 15.6%. The energy and fuel component is small, but has declined slowly and steadily from 1% to 0.6%.

**Fabricated Metal Products:** Total costs to shipments fell two percentage points to 77% by 1997 as a result of small declines in each component. The wages and salaries component is relatively large but has changed little, falling to 24.4% from 25.1% of shipments while supplies and materials remained low at 50.9% in 1997.

**Machinery:** This industry also has a large wage component but it has fallen from 24.6% to 20.2% relative to shipments. Supplies remained relatively stable at 53.2% in 1997 and energy and fuel costs at 0.8% having declined from 1.2%. Cumulatively, these declines led to total costs to shipments falling to 74% from 78%.

**Plastic Products:** Dropping materials and supplies costs were responsible for most of the drop in total costs to shipments, from 79% to 74%. This component fell from 57.3% of shipments to 53.3%. Energy and fuel was at 2.1% and wages and salaries at 19% relative to shipments in 1997.

**Clothing:** The wage component is large for this industry but has fallen from 28.9% to 24% relative to shipments. Energy and fuel remained at about 0.7% and supplies too remained essentially unchanged, closing at 50.7% of shipments in 1997.

**Food:** An already small salaries and wages component fell further from 11.5% of shipments to 10.9% by 1997. Energy and fuel remained a minor and relatively unchanged component at 1.3% in 1997, while the materials and supplies component remained high but declined from 71.6% to 68%.

**Furniture and Fixtures:** The wages and salaries component is also high for this industry at 23.6%, down from about 27% in 1983. Energy and fuel also fell from 1.4% to 1.1%, but materials and supplies increased slightly from 48.3% to 50.7% of shipments.

**Primary Metal Products:** The wages and salaries, and energy and fuel components both fell during the period, but both remain above the ratios for the manufacturing sector as a whole. The wages component dropped to 15.9% from 22.7%, while energy and fuel fell from 6.8% to 6.3%. Materials and supplies increased from 53.3% to 55.7% relative to shipments.