

# MOSST Background Paper

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Performance of Canadian  
Manufacturing Industries  
by Levels of Research  
Intensity

July 1978



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## I INTRODUCTION

It is now generally accepted that technology and technological innovation play an important role in the long-term rate of growth of an economy. Technology is closely related to research and development, with technological progress dependent on R&D. Although the existing knowledge about the relationship between R&D and economic growth is circumscribed, all the available evidence indicates that R&D is an important contributor to economic growth and productivity 1/.

Research and development is generally defined as investigative work carried out to acquire new scientific and technological knowledge, to devise and develop new products or processes. If R&D leads to the introduction of new products, particularly new intermediate goods, which raise the output per unit of input, it contributes to increased productivity. If the results of R&D lead to better and more efficient techniques in producing existing products, the end result is again an increase in productivity.

Improved productivity is one of the key elements which leads to growth in real incomes. Obviously technological change is not the only factor which affects a nation's rate of growth in productivity. There are many other factors, such as improved labour skills and education, increases in capital intensity, economies of scale, and improved management techniques, which have an important bearing on the general health of the economy. Nevertheless, although the exact contribution of the above factors on the overall rate of growth in productivity is not known precisely, the existing evidence strongly suggests that technological change is one of the key factors in productivity growth.

Although R&D is an important contributor to technological change and innovation, it is not an end in itself. It is only when R&D is coupled with product design, engineering, manufacturing and marketing that R&D becomes a commercial reality. R&D, and indeed the whole technological innovation spectrum, is a complex process which is subject to varying degrees of market uncertainty. However, the failure of a firm or an industry to be innovative may mean failure of the firm or the industry itself with consequent implications for the general economy 2/.

1/ An excellent summary of the relationship between research and development and economic growth/productivity is to be found in, "R&D and Economic Growth/Productivity: National Science Foundation: Washington, D.C. 1971".

2/ "Science Indicators 1976" Report of the National Science Board, Washington, D.C. 1977.

The research and development conducted by industry establishes the technological base for an indigenous innovative capability. That technological base, aside from generating new innovative alternatives, also facilitates the successful adaptation of technology developed elsewhere. Moreover, it is not only those companies performing research and development which benefit from such work, but also those industries which purchase goods embodying innovations developed by others. This diffusion of technology serves to strengthen the economy generally by increasing the overall level of productivity.

The purpose of this paper is to assess the performance of R&D intensive industries relative to those manufacturing industries which do little or no R&D in Canada. The performance of the industries is assessed in terms of employment, output, productivity and price movements over the 1961 to 1974 time period<sup>3/</sup>.

Section II of the paper presents an overview of research and development in Canadian manufacturing industries and compares the prevailing situation to that of other major industrial countries. In Section III, the scheme for classifying industries by levels of research intensity is discussed and Section IV presents the results of the analysis. Concluding comments are contained in Section V.

## II RESEARCH AND DEVELOPMENT IN CANADIAN MANUFACTURING

### A An Overview

Research and development is defined as investigative work carried out to acquire new scientific and technological knowledge, to devise and develop new products and processes, or to apply newly acquired knowledge in making technically significant improvements to existing products or processes.

<sup>3/</sup> In this paper productivity is defined as real output per person. The value added implicit price index is used as a measure to determine the movement of prices.

Manufacturing industries generally account for over 80 per cent of total intramural research and development <sup>4/</sup> performed by Canadian Business Enterprises (see table 1). Primary industries (mines, oil and gas wells) perform about six per cent of R&D and service industries (transportation, public utilities, and consultants) perform about ten per cent of total intramural R&D.

TABLE 1

TOTAL INTRAMURAL R&D EXPENDITURES, BY INDUSTRY

1971-77

CURRENT DOLLARS (\$ MILLIONS)

Industry		1971	1972	1973	1974	1975	1976	1977
Primary Industries		17.3	26.7	29.9	35.3	40.8	41.3	49.5
	%	3.7	5.8	5.9	5.8	5.9	5.3	5.8
Manufacturing Industries		405.7	386.5	430.3	516.7	571.6	645.0	697.2
	%	86.8	84.2	85.4	84.6	82.6	82.6	82.4
Service Industries		44.5	46.3	43.8	58.9	79.8	94.8	99.7
	%	9.5	10.0	8.7	9.6	11.5	12.1	11.8
TOTAL		467.5	459.5	504.0	610.9	692.2	781.1	846.4
	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Statistics Canada

<sup>4/</sup> Intramural R&D expenditures include all funds used for work performed in-house within the industry, including work financed by others. Total intramural R&D includes both current and capital expenditures. Capital expenditures usually account for between six to eight per cent of total intramural R&D.



Total intramural R&D in the manufacturing industries has increased in current dollars each year since 1972 and amounted to approximately \$700 million by 1977. (Total R&D expenditures in Canada for 1977 amounted to over \$1.9 billion.) However, in constant 1971 dollars, although R&D expenditures have increased since 1972, the level of spending in 1977 was still below that attained in 1971. Furthermore, R&D expenditures in the manufacturing industries, as a proportion of GNP, have been declining since 1971 when the ratio was 0.43 per cent. By 1977, 0.33 per cent of GNP was devoted to R&D in manufacturing (see table 2).

TABLE 2

Total Intramural R&D Expenditures in  
Canadian Manufacturing  
(\$ Millions)

	R&D CURRENT \$	GNP CURRENT \$	R&D AS A % OF GNP	R&D <sup>1/</sup> 1971 \$	GNP <sup>1/</sup> 1971 \$
1971	405.7	94,450	0.43	405.7	94,450
1972	386.5	105,234	0.37	368.1	100,248
1973	430.3	123,560	0.35	375.5	107,812
1974	516.7	147,175	0.35	392.3	111,766
1975	571.6	165,445	0.34	390.2	112,955
1976	645.0	190,027	0.34	402.1	118,484
1977	697.2	209,400	0.33	404.4	121,454

Source: Statistics Canada

<sup>1/</sup> GNP implicit price index is used to convert current dollars to 1971 constant dollars.

B R&D by Performer and by Source of Funds

Table 3 shows the sources of funds for intramural R&D in manufacturing industries at the two digit SIC level in 1975 and the total amount of R&D performed by each industry.

As is readily apparent, total intramural industrial R&D is concentrated in a few manufacturing industries. The following six industries accounted for approximately 85 per cent of all intramural R&D expenditures, primary metals, machinery (excluding electrical machinery), transportation equipment, electrical products, petroleum products, and chemicals and chemical products. The electrical products industry is the largest performer of intramural R&D and accounts for about 30 per cent of industrial R&D expenditures.

This concentration of industrial R&D is not unique to Canada. For instance, in the United States, six industries also accounted for over 85 per cent of all industrial R&D spending in 1974. They were: electrical equipment and communications, aircraft and missiles, machinery, motor vehicles and other transportation equipment, chemicals and allied products, and professional and scientific equipment 5/.

In terms of funding, Canadian sources provided over 92 per cent of the total intramural R&D performed in manufacturing industries. Industry financed about 80 per cent of its intramural R&D, with the federal government providing about 12 per cent of the funds. Foreign sources funded about 7 per cent of industrial R&D.

The federal government supports research and development in industry through grants, contracts and loans. The principal financial support of industrial R&D is provided through a group of special programs designed to develop research capacity in Canadian industry by assisting current R&D. Some of the major programs are the National Research Council's Industrial Research Assistance Program (IRAP), the Defense Industry Production Program (DIP), the Program for the Advancement of Industrial Technology (PAIT) and the Defence Industrial Research Program (DIR). It should be noted that since the grants given under the Industrial Research and Development Incentives Act (IRDIA) were for R&D performed previously, Statistics Canada does not include them in the direct government aid reported by industry in its survey on Industrial Research and Development Expenditures in Canada 6/.

Over 60 per cent of federal funds went to two industries (transportation equipment and electrical products). The aircraft and parts sector received \$21.7 million of the \$23.1 million in federal funds going to the transportation equipment industry.

5/ National Science Foundation. "Science Indicators, 1976" U.S. Government Publishing Office, Washington, D.C., 1977.

6/ See Statistics Canada, "Industrial Research and Development Expenditures in Canada", 13-202.

Foreign sources provided \$43.3 million for R&D in Canadian manufacturing. Over two-thirds of the funds (from foreign sources) went to two industries: machinery industries and electrical products.

TABLE 3

Sources of Funds for Intramural R&D  
Manufacturing Industries 1975  
(\$ Millions)

	Canadian Sources		Foreign Sources	Total
	Industry	Federal <sup>1/</sup> Government		
01 Food & Beverages and 02 Tobacco Pds.	22.2	2.4	*	24.6
03 Rubber & Plastic Pds.	4.5	0.4	0.7	5.6
04 Leather Inds.	*	*	*	*
05 Textile Inds.	5.0	0.3	*	5.3
06 Knitting Mills	*	*	*	*
07 Clothing Inds.	*	*	*	*
08 Wood Inds.	2.5	0.3	*	2.8
09 Furniture & Fixtures	0.5	0.1	*	0.6
10 Paper & Allied Inds.	24.3	1.7	1.1	27.1
11 Printing, Publishing Inds.	*	*	*	*
12 Primary Metal Inds.	58.8	1.5	2.6	63.0
13 Metal Fabricating	8.8	1.1	*	9.9
14 Machinery Inds.	47.1	9.3	17.2	73.6
15 Transportation Equipment	36.5	23.1	4.4	64.0
16 Electrical Pds.	127.0	19.9	11.8	158.7
17 Non-Metallic Minerals	4.4	0.4	0.1	4.9
18 Petroleum & Coal Pds.	43.3	0.8	1.4	45.5
19 Chemical & Chemical Pds.	64.5	4.3	3.6	72.4
20 Misc. Mfg. Inds. <sup>2/</sup>	10.8	2.4	0.4	13.6
Total	460.2	68.0	43.3	571.6

Source: Statistics Canada

<sup>1/</sup> Excluding grants received under the Industrial Research and Development Incentives Act (IRDIA)

<sup>2/</sup> The numbers in this row are residual figures and do not correspond to the miscellaneous manufacturing industries category of the SIC classification

TABLE 4

CURRENT INTRAMURAL R&D EXPENDITURES  
BY MANUFACTURING INDUSTRY & OWNERSHIP  
(\$MILLIONS, 1975)

Industry	Canadian Controlled Companies	Foreign Controlled Companies	Total
01 Food & Beverages and 02 Tobacco Pds.	12.2	9.6	21.8
03 Rubber & Plastics Pds	x	x	5.2
04 Leather Inds.	-	-	-
05 Textile Inds.	1.4	3.7	5.1
06 Knitting Mi-ls	-	-	-
07 Clothing Inds.	-	-	-
08 Wood Inds.	x	x	2.4
09 Furniture & Fixtures	x	x	0.6
10 Paper & Allied Inds.	16.8	8.2	25.0
11 Printing, Publishing Inds.	-	-	-
12 Primary Metal Inds.	46.2	7.5	53.7
13 Metal Fabricating Inds.	5.5	3.9	9.4
14 Machinery Inds.	20.3	44.4	64.7
15 Transportation Equipment	28.3	34.4	62.7
16 Electrical Pds.	88.0	60.7	148.7
17 Non-Metallic Minerals	1.4	3.2	4.6
18 Petroleum & Coal Pds.	x	x	39.9
19 Chemical & Chemical Pds.	20.7	44.7	65.4
20 Other Mfg. Inds.	8.9	3.6	12.5
TOTAL Manufacturing	(252.3) <sup>1</sup>	(269.2) <sup>1</sup>	521.7

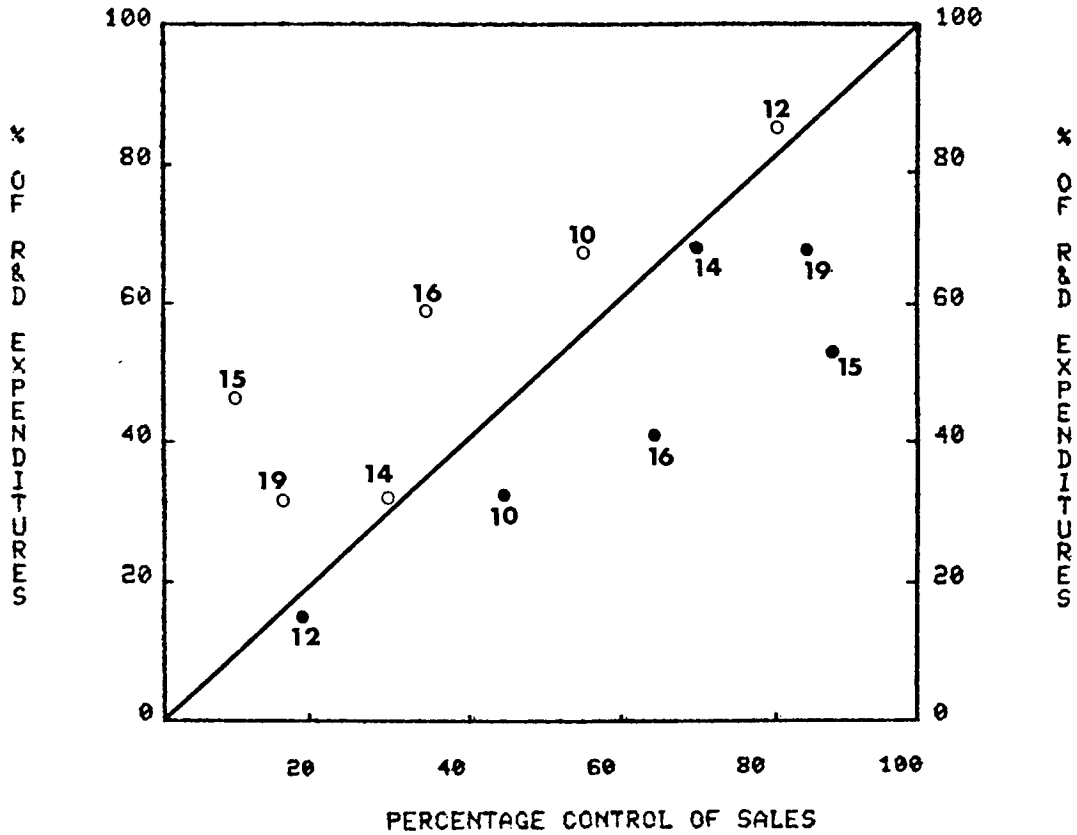
Source: Statistics Canada

X Confidential

1 Totals include confidential data

CHART I

RELATIVE R&D PERFORMANCE: CANADIAN-CONTROLLED  
AND FOREIGN-CONTROLLED MANUFACTURING INDUSTRIES



- CANADIAN CONTROLLED
- FOREIGN CONTROLLED

- 10- PAPER & ALLIED PRODUCTS
- 12- PRIMARY METALS
- 14- MACHINERY INDUSTRIES

- 15- TRANSPORTATION EQUIPMENT
- 16- ELECTRICAL PRODUCTS
- 19- CHEMICAL & CHEMICAL PRODUCTS

C R&D in Manufacturing by Ownership

In 1975, \$521.7 million were spent on current intramural R&D in Canadian manufacturing (see table 4). This figure does not include capital expenditures on R&D which amounted to approximately \$50 million. Canadian-controlled companies and foreign-controlled companies each performed approximately half of the R&D. Furthermore, about 85 per cent of the R&D performed by foreign-controlled companies was by U.S. controlled companies.

Foreign-controlled companies performed more R&D than Canadian-controlled companies in the following major industries: machinery (excluding electrical machinery), transportation equipment, and chemicals and chemical products. On the other hand, Canadian-controlled companies did more R&D in pulp and paper industries, primary metals, and electrical products in industries. However, when the level of R&D expenditures is related to sales, a different picture emerges when comparing foreign-controlled firms to their domestic counterparts.

TABLE 5

DEGREE OF FOREIGN CONTROL BY SALES  
OF CANADIAN MANUFACTURING INDUSTRIES

Industry	%	Industry	%
01 Food & Beverages and	41.8	11 Printing, Publishing Inds.	11.2
02 Tobacco Pds.			
03 Rubber & Plastics Pds	90.7	12 Primary Metal Inds.	18.9
04 Leather Inds.	22.1	13 Metal Fabricating Inds.	41.2
05 Textile Inds.	55.7	14 Machinery Inds.	69.7
06 Knitting Inds.	19.2	15 Transportation Equipment	88.9
07 Clothing Inds.	11.8	16 Electrical Pds.	65.4
08 Wood Inds.	22.6	17 Non-Metallic Minerals	56.1
09 Furniture & Fixtures	16.2	18 Petroleum & Coal Pds.	99.1
10 Paper & Allied Inds.	45.3	19 Chemical & Chemical Pds.	82.7
		20 Misc. Mfg. Inds.	48.5
		Total Manufacturing	57.2

Source: Corporations and Labour Unions Returns Act, Statistics Canada, 61-210

Table 5 shows the degree of foreign control by sales of corporations of manufacturing industries in Canada for 1974. A corporation is considered to be foreign-controlled if 50 per cent or more of its voting rights are known to be held outside Canada or are held by one or more Canadian corporations that are themselves foreign-controlled <sup>7/</sup>.

Table 6 and the accompanying chart (Chart I) relate the level of R&D performed by Canadian-controlled and foreign-controlled companies to their respective levels of sales for the following six industries which perform over 80 per cent of the R&D: paper and allied industries, primary metals industry, machinery industries, transportation equipment, electrical products, and chemicals and chemical products.

TABLE 6

Relative R&D Performance: Canadian-Controlled  
and Foreign-Controlled Manufacturing Industries

Industry	<u>Canadian-Controlled</u>		<u>Foreign-Controlled</u>	
	% Sales	% R&D	% Sales	% R&D
10 Paper & Allied Pds.	54.7	67.2	45.3	32.8
12 Primary Metals	81.1	86.0	18.9	14.0
14 Machinery Inds.	30.7	31.4	69.7	68.6
15 Transportation Equipment	11.1	45.1	88.9	54.9
16 Electrical Products	34.6	59.2	65.4	40.8
19 Chemical & Chemical Pds.	17.3	31.7	82.7	68.8

Source: Based on data from Statistics Canada

<sup>7/</sup> "Corporations and Labour Unions Returns Act", Page 83,  
Cat G1-210, Statistics Canada, Jan. 1977

The table and the chart indicate that in every industry the R&D expenditures of Canadian-controlled companies relative to their level of sales were higher than those of their foreign-controlled counterparts. On the basis of these results it is apparent that, for a given industry, the ownership of a particular company is an essential variable in determining the degree of its involvement in R&D activity.

#### D R&D Personnel in Canadian Manufacturing

There were 18,512 persons engaged in research and development in Canadian manufacturing industries in 1975 (see table 7). Of this total, approximately 40 per cent were professional scientists and engineers, with technicians and other supporting staff accounting for 60 per cent of the total R&D personnel.

As in the case of R&D expenditures, personnel engaged in R&D are also concentrated in a few industries. The same six industries - primary metals, machinery (excluding electrical machinery), transportation equipment, electrical products, petroleum products and chemicals - accounted for over 80 per cent of R&D personnel. Similarly, the electrical products industry is the largest employer of R&D personnel and accounted for over 28 per cent of the total R&D personnel in 1975.

#### E Some International Comparisons

Although a certain amount of caution has to be entertained in making international comparisons because of differences in data-gathering techniques, differences in methodologies, etc., it is nevertheless illuminating to compare Canada's R&D effort in manufacturing activities with that of the major industrial countries.

While Canada currently devotes less than 1 per cent of its GNP to total research and development, most industrialized countries allocate a substantially higher proportion of their GNP to R&D. Furthermore, in Canada, only one-third of one per cent of the GNP is devoted to R&D in the manufacturing sector. This is in sharp contrast to most of the other industrialized countries where the manufacturing sector typically accounts for 1 per cent of the GNP. For example, the United States devotes over 1.5 per cent of its GNP to R&D in the manufacturing sector. Although Italy devotes only about 1 per cent of its GNP to R&D, the manufacturing sector accounts for about half of the total R&D expenditures (see chart II).



TABLE 7

NUMBER OF PERSONS ENGAGED IN R&D  
IN CANADIAN MANUFACTURING  
(FULL-TIME EQUIVALENTS - 1975)

Industry	Professional Staff <u>1/</u>	Supporting Staff <u>2/</u>	Total Personnel
01 Food & Beverages and 02 Tobacco Pds.	344	515	859
03 Rubber & Plastics Pds.	101	115	216
04 Leather Inds.	*	*	*
05 Textile Inds.	83	122	205
06 Knitting Mills	*	*	*
07 Clothing Inds.	*	*	*
08 Wood Inds.	30	38	68
09 Furniture & Fixtures	9	19	28
10 Paper & Allied Inds.	434	611	1,045
11 Printing, Publishing Inds.	*	*	*
12 Primary Metal Inds.	743	1,303	2,046
13 Metal Fabricating Inds.	163	197	360
14 Machinery Inds.	767	1,422	2,189
15 Transportation Equipment	762	1,439	2,201
16 Electrical Pds.	2,317	2,922	5,239
17 Non-Metallic Minerals	71	114	185
18 Petroleum & Coal Pds.	326	478	804
19 Chemical & Chemical Pds.	1,302	1,310	2,612
20 Misc. Mfg. Inds. <sup>3/</sup>	186	269	455
TOTAL	7,638	10,874	18,512

Source: Statistics Canada

1/ Professional staff includes scientists and engineers and administrators of R&D

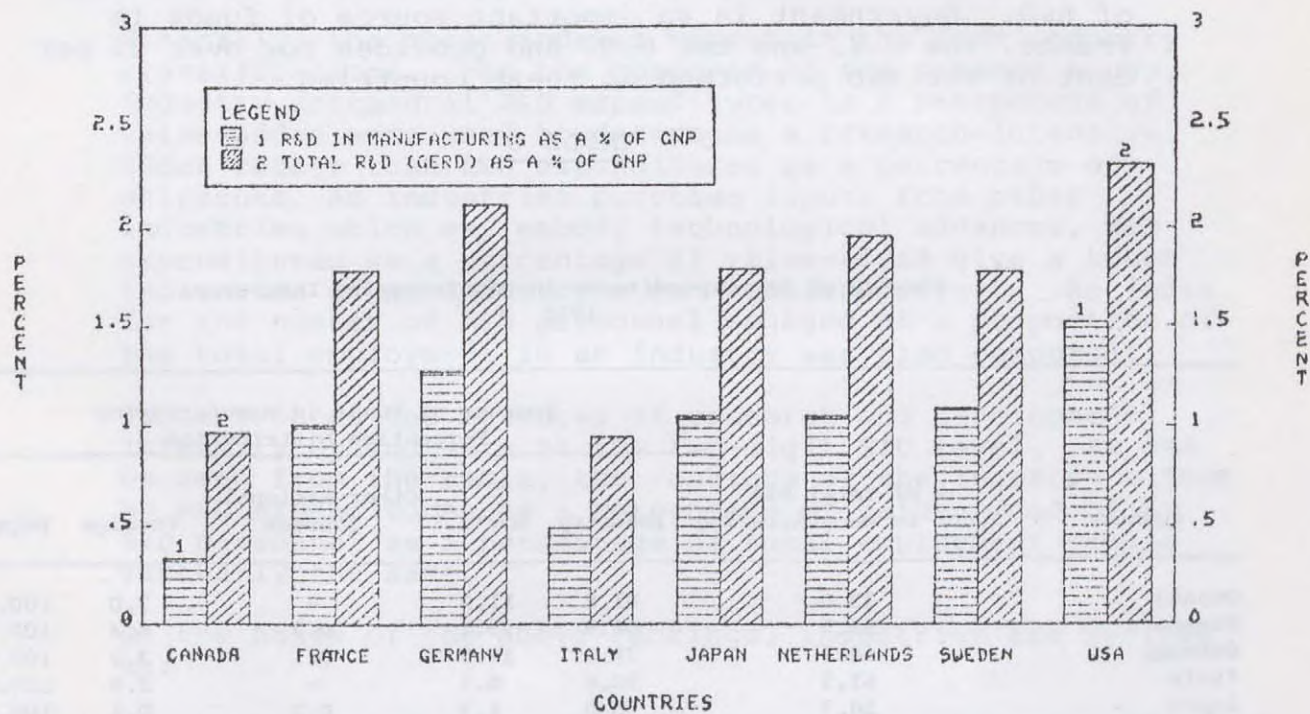
2/ Supporting staff includes technicians and other support staff engaged in R&D

3/ The numbers in this row are residual figures and do not correspond to the miscellaneous manufacturing industries category of the SIC classification.

## CHART II

### R&D AS PERCENT OF GNP

1975



SOURCE : OECD

Table 8 represents a summary of intramural R&D expenditures in manufacturing industries for the major OECD countries. In Canada, approximately one-third of the total R&D expenditures by all sectors is performed in the manufacturing sector. However, in most OECD countries, more than 50 per cent of the total national R&D effort is accounted for in the manufacturing sector.

In terms of sources of funds for research and development, Canadian industry finances over 80 per cent of its intramural R&D. In Japan, industry finances 98 per cent of its intramural R&D, whereas in the United Kingdom and the United States industry finances approximately 63 per cent of R&D. Government is an important source of funds in France, the U.K. and the U.S. and provides for over 25 per cent of the R&D performed in these countries.

TABLE 8

Summary of R&D Expenditures in Manufacturing Industries  
1975

Country	% of Total R&D Spent in Manufacturing	Sources of Funds in Manufacturing Percentage Distribution					Total
		Industry	Gov't.	Other National Sources	Foreign		
Canada	33.0	81.8	11.2	-	7.0	100.0	
France	56.5	68.9	25.4	0.3	5.4	100.0	
Germany	60.7	78.8	17.9	0.1	3.2	100.0	
Italy	51.5	90.6	6.5	-	2.9	100.0	
Japan	58.7	98.0	1.7	0.2	0.1	100.0	
Netherlands	54.0	-	-	-	-	-	
Sweden	61.6	81.9	15.9	-	2.1	100.0	
United Kingdom	-	62.8	20.9	-	6.3	100.0	
United States	65.7	62.8	37.2	-	-	100.0	

Source" OECD Science Resources Newsletter, Winter 1977/78

Although the definition of a research-intensive industry is imprecise at best, most studies to determine research-intensive industries use one or more of the following indexes for classifying industries: 1) R&D expenditures as a percentage of shipments or value-added; 2) the number of R&D personnel engaged as a proportion of the total employment in an industry; 3) average skill level of workers.

Generally, the above indexes result in the same industry classifications. For the purposes of the present study, industry intramural R&D expenditures as a percentage of value-added were used to determine a research-intensive index rather than R&D expenditures as a percentage of shipments. As industries purchase inputs from other industries which may embody technological advances, R&D expenditures as a percentage of value-added give a truer indication of an industry's own research effort. An index for the number of R&D personnel engaged as a proportion of the total employment in an industry was also computed.

Table 9 shows the measures of research and development intensity by industry at the two-digit SIC level. As can be seen from the table, the rankings of the industry either by R&D expenditures as a percentage of value-added or by R&D personnel as a percentage of total employment remain virtually the same.

On the basis of the above rankings, industries are defined as:

1. Research-intensive (RI) if the ratio of R&D expenditures to value-added (R&D/VA) is greater than 3 and the ratio of R&D personnel to total employment by industry (R&D/TE) is greater than 2;
2. Medium-research-intensive (MRI) if R&D/VA is between 1 and 3 and R&D/TE is between 0.75 and 2;
3. Low-research-intensive (LRI) if R&D/VA is less than 1 and R&D/TE is less than 0.75;
4. Industries which perform no R&D.

TABLE 9

Measures of R&D Intensity, by Industry

Industry	R&D Expenditures as a Percent of Value Added (1974)	Rank	R&D Personnel as a Percent of Total Employment (1975)	Rank
01 Food & Beverages	0.53	10	0.37	9
02 Tobacco Pds.				
03 Rubber & Plastic Pds.	0.63	8	0.41	8
04 Leather Inds.	*	*	*	*
05 Textile Inds.	0.37	11	0.29	11
06 Knitting Mills	*	*	*	*
07 Clothing Inds.	*	*	*	*
08 Wood Inds.	0.11	14	0.07	13
09 Furniture & Fixtures	0.12	13	0.06	14
10 Paper & Allied Inds.	1.04	7	0.82	7
11 Printing, Publishing Inds.	*	*	*	*
12 Primary Metals Inds.	2.01	6	1.70	5
13 Metal Fabricating	0.30	12	0.24	12
14 Machinery Inds.	4.26	3	2.37	4
15 Transportation Equipment	2.18	5	1.38	6
16 Electrical Pds.	7.37	1	4.16	2
17 Non-Metallic Minerals	0.54	9	0.33	10
18 Petroleum & Coal Pds.	6.48	2	4.66	1
19 Chemical & Chemical Pds.	3.55	4	3.25	3
20 Misc. Mfg. Inds.	*	*	*	*

Source: Based on data from Statistics Canada

Thus, based on the above definitions, the industries were re-grouped as follows:

1. Research-Intensive Industries:
  - 14 Machinery Industries
  - 16 Electrical Products
  - 18 Petroleum Products
  - 19 Chemicals & Chemical Products
  
2. Medium-Research-Intensive Industries:
  - 10 Paper and Allied Products
  - 12 Primary Metals
  - 15 Transportation Equipment
  
3. Low-Research-Intensive Industries:
  - 01 & 02 Food, Beverages and Tobacco Products
  - 03 Rubber and Plastic Products
  - 05 Textile Industry
  - 08 Wood Industry
  - 09 Furniture and Fixtures
  - 13 Metal Fabricating
  - 17 Non-Metallic Minerals
  
4. Industries which perform no research and development:
  - 04 Leather Industries
  - 06 Knitting Mills
  - 07 Clothing Industries
  - 11 Printing and Publishing
  - 20 Miscellaneous Manufacturing Industries

Research-intensive and medium-research-intensive industries account for over 88 per cent of total intramural R&D performed by Canadian manufacturing and for 87 per cent of the total personnel engaged in R&D.

#### IV THE RESULTS

##### A The Performance of Canadian Manufacturing Industries by Levels of Research Intensity

Total employment in Canadian manufacturing industries increased by over 433 thousand, from 1.35 million in 1961, to 1.78 million by 1974. In 1961 research-intensive industries accounted for about 16 per cent of total employment in manufacturing industries and by 1974 the share had increased to approximately 18 per cent (see table 10). Similarly, medium-research-intensive industries increased their share of employment from 21.3 per cent in 1961 to 23.8 per cent by 1974. On the other hand, the share of employment in both low-research-intensive industries and industries which perform no R&D decreased over the time period.

TABLE 10

EMPLOYMENT IN CANADIAN  
MANUFACTURING INDUSTRIES

('000's)

		1961	1974
Research Intensive Industries	%	219.7 16.2	319.6 17.9
Medium-Research Intensive Industries	%	287.6 21.3	425.3 23.8
Low-Research Intensive Industries	%	568.0 42.0	729.6 40.9
Industries which perform no R&D	%	277.5 20.5	311.1 17.4
Total Manufacturing	%	1,352.6 100.0	1,786.0 100.0

Source: Statistics Canada

In terms of actual employment there were approximately 100 thousand jobs created in the research-intensive industries from 1961 to 1974, representing an increase of over 45 per cent. Employment in medium-research-intensive industries increased by over 137 thousand (47.8 per cent) during the same time period. On the other hand, although employment in low-research-intensive industries increased by over 61 thousand, the percentage increase was about 28 per cent. Employment in industries which performed no research and development increased by 33 thousand or 12 per cent over the 1961 to 1974 period.

In terms of real output (in constant 1971 dollars), research-intensive and medium-research-intensive industries increased their share of output and by 1974 both groups accounted for approximately 49 per cent of total output in manufacturing industries (see table 11). By contrast, the share of output accounted for by low-research and no-research industries decreased.

Although real output per person has increased in each of the four manufacturing groups since 1961, the performance of research-intensive and medium-research-intensive industries was superior to that of low-research-intensive industries and industries which performed no R&D (see table 12).

TABLE 11

PERCENTAGE DISTRIBUTION OF REAL OUTPUT  
IN MANUFACTURING INDUSTRIES

	1961	1974
Research Intensive Industries	18.1	20.6
Medium-Research Intensive Industries	25.8	28.3
Low-Research Intensive Industries	41.7	38.6
Industries which perform no R&D	15.8	12.5
Total Manufacturing	100.0	100.0

Source: Statistics Canada



TABLE 12

REAL OUTPUT PER PERSON  
(Constant 1971 dollars)

	1961	1974	% Increase
Research-Intensive Industries	8,500	14,700	72.9
Medium-Research Intensive Industries	9,300	15,100	62.4
Low-Research Intensive Industries	7,600	12,000	57.9
Industries which perform no R&D	5,900	9,200	55.9
Total Manufacturing	7,700	12,700	64.9

Source: Based on data from Statistics Canada

Table 13 and the accompanying chart, Chart III, show the average annual rates of growth for employment, output, productivity and prices for the four industry groups and total manufacturing. As can be seen from the table and chart, research-intensive and medium-research intensive industries clearly outperform low-research and no-research industries in each of the four indicators.

TABLE 13

AVERAGE ANNUAL RATES OF GROWTH  
1961 - 1974  
PERCENT

	Employment	Real <sup>1</sup> Output	Productivity <sup>2</sup>	Prices <sup>3</sup>
Research-Intensive Industries	2.42	6.41	4.49	1.39
Medium-Research-Intensive Industries	2.75	6.60	3.95	1.64
Low-Research-Intensive Industries	1.61	5.19	3.47	3.13
No Research Industries	0.73	3.85	3.14	3.25
Total Manufacturing	1.87	5.79	3.82	2.37

<sup>1</sup> 1971 Dollars

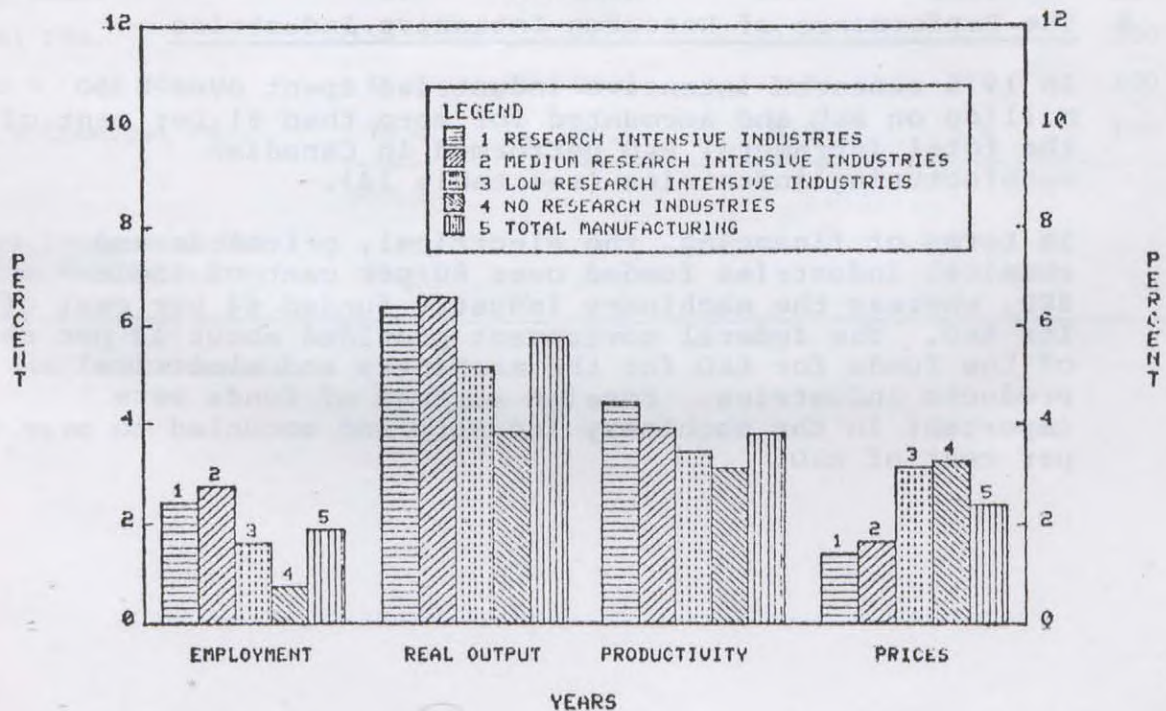
<sup>2</sup> Real Output Per Person

<sup>3</sup> Value-added implicit price index

Source: Based on data from Statistics Canada

CHART III

AVERAGE ANNUAL RATES OF GROWTH  
1961 - 1974



Research-intensive industries registered the highest average annual rate of growth in productivity and had the lowest rate of price increases, whereas medium-research-intensive industries had the highest average annual rate of growth in output and employment.

Research-intensive industries outperformed low-research-intensive industries by registering over the 1961-1974 period: 1) 50.3 per cent higher growth in employment; 2) 23.5 per cent higher growth in output; 3) 29.4 per cent higher growth in productivity; 4) 55.6 per cent lower growth in prices.

Similarly, research-intensive industries outperformed industries which did no research and development by: 1) 231.5 per cent higher growth in employment; 2) 66.5 per cent higher growth in output; 3) 43.0 per cent higher growth in productivity; 4) 57.2 per cent lower growth in prices.

Medium-research-intensive industries outperformed low-research-intensive industries by registering over the 1961-1974 period: 1) 70.8 per cent higher growth in employment; 2) 27.2 per cent higher growth in output; 3) 13.8 per cent higher growth in productivity; 4) 27.6 per cent lower growth in prices.

Medium-research-intensive industries also outperformed industries which did no R&D by registering: 1) 276.7 per cent higher growth in employment; 2) 71.4 per cent higher growth in output; 3) 25.8 per cent higher growth in productivity; 4) 49.5 per cent lower growth in prices.

## B The Performance of Research-Intensive Industries

In 1975 research-intensive industries spent over \$350 million on R&D and accounted for more than 61 per cent of the total intramural R&D performed in Canadian manufacturing industries (see table 14).

In terms of financing, the electrical, petroleum and chemical industries funded over 80 per cent of their R&D, whereas the machinery industry funded 64 per cent of its R&D. The federal government provided about 12 per cent of the funds for R&D for the machinery and electrical products industries. Foreign sources of funds were important in the machinery industry and amounted to over 23 per cent of R&D.

Intramural R&D expenditures in current dollars increased in absolute terms since 1971 for the four research-intensive industries (see chart IV). However, in constant (1971) dollar terms, only the petroleum and coal products industry registered positive growth. In the other industries, there was virtually no growth in real R&D expenditures.

In terms of employment, the machinery industry had the highest average annual rate of growth (3.48 per cent). There was very little growth in employment in the petroleum and coal products industry, which is a reflection of the extreme capital intensity of the industry. In terms of the other indicators, the high productivity performance of the chemical industry was coupled with a very low rate of increase in prices (see table 15).

TABLE 14

Research & Development Expenditures, 1975  
 Research-Intensive Industries  
 (\$ Millions)

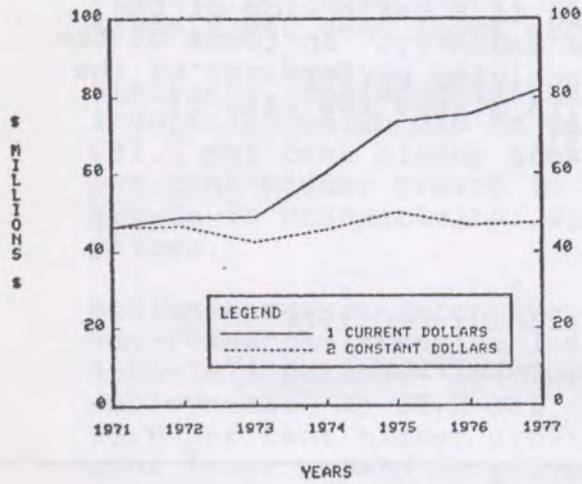
	R&D \$ Millions	% Distribution of Sources of Funds			
		Industry	Federal Gov't.	Foreign	Total
Machinery Inds.	73.6	64.0	12.6	23.4	100
Electrical Pds.	158.7	80.0	12.5	7.5	100
Petroleum & Coal Pds.	45.5	95.2	1.8	3.0	100
Chemical & Chemical Pds.	72.4	89.1	5.9	5.0	100
	350.2				
% of total intramural R&D in Canadian Manufacturing	61.3				

Source: Statistics Canada

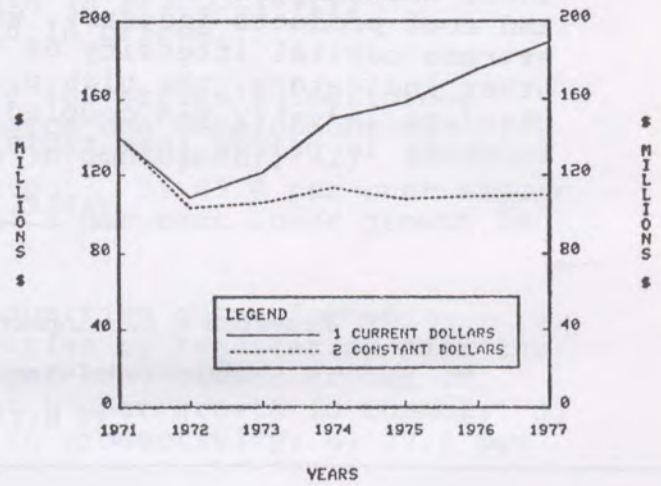
CHART IV

R&D Expenditures in Research-Intensive Industries

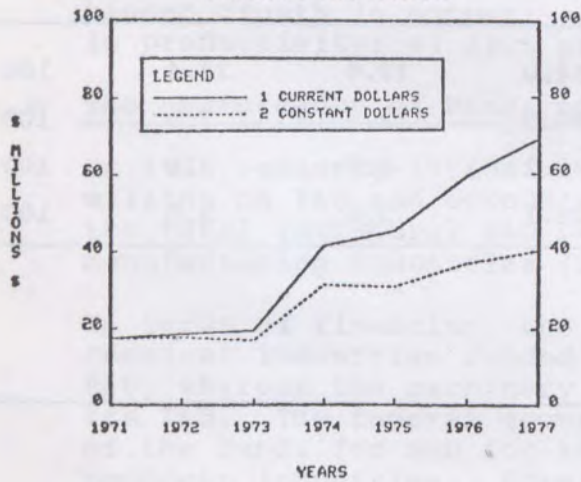
TOTAL INTRAMURAL R&D EXPENDITURES FOR 1971 -77  
MACHINERY INDUSTRIES



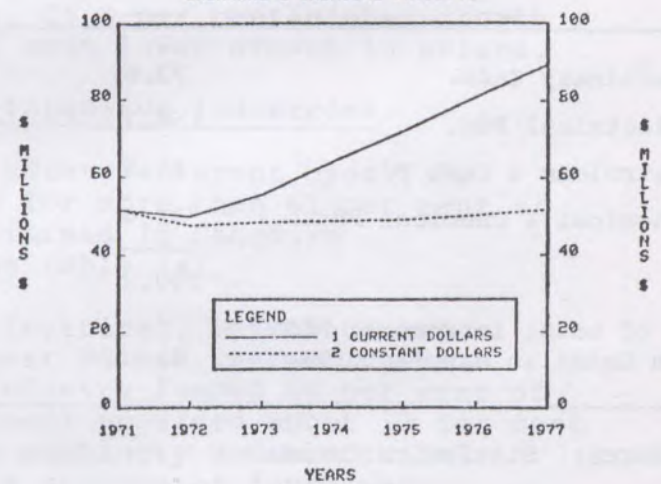
TOTAL INTRAMURAL R&D EXPENDITURES FOR 1971 -77  
ELECTRICAL PRODUCTS



TOTAL INTRAMURAL R&D EXPENDITURES FOR 1971 -77  
PETROLEUM & COAL PRODUCTS



TOTAL INTRAMURAL R&D EXPENDITURES FOR 1971 -77  
CHEMICAL & CHEMICAL PRODUCTS



SOURCE : STATISTICS CANADA : CAT 13-003

TABLE 15

AVERAGE ANNUAL RATES OF GROWTH  
RESEARCH-INTENSIVE INDUSTRIES  
1961 - 1974

	Employment	Real Output	Productivity	Prices
Machinery	3.48	5.72	4.23	2.79
Electrical Products	2.49	6.99	4.14	1.73
Petroleum & Coal Products	0.29	4.70	4.87	1.15
Chemical & Chemical Products	1.76	6.86	5.38	0.19
Total R.I. Industries	2.42	6.41	4.49	1.39

Source: Based on data from Statistics Canada

C The Performance of Medium-Research-Intensive Industries

Medium-research-intensive industries accounted for approximately 27 per cent of the total intramural R&D performed in 1975 by Canadian manufacturing. The paper and allied industries and the primary metal industries financed the bulk of their R&D. The transportation equipment industry, on the other hand, received about 36 per cent of its funds for R&D from the federal government and financed less than 60 per cent internally (see table 16).

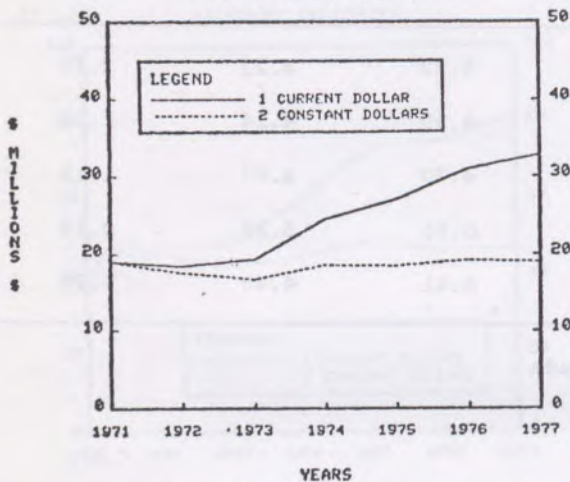
From 1971 to 1977 there was an increase in R&D expenditures in current dollars in the three medium-research-intensive industries. However, in constant (1971) dollars the growth in R&D expenditures was erratic in both primary metals and transportation equipment. There was no growth in the paper and allied industries (see chart V).

The transportation equipment industry registered the highest rate of growth in employment (2.75 per cent), output (6.6 per cent), productivity (3.95 per cent) and also registered the lowest rate of increase in prices (0.88 per cent) over the 1961-1974 period (see table 17).

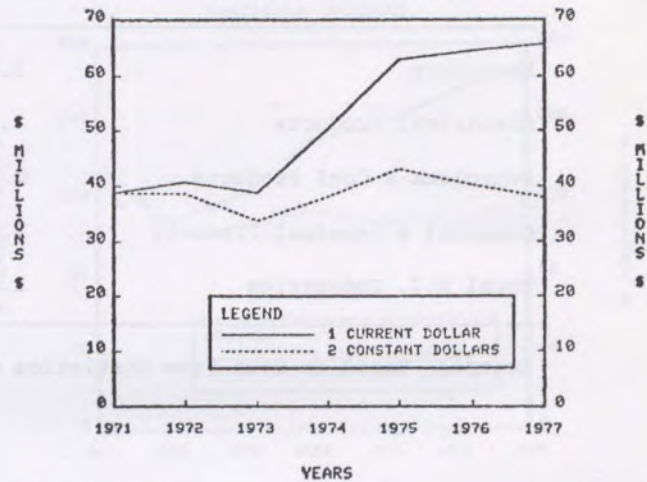
CHART V

R&D Expenditures in Medium-Research-Intensive Industries

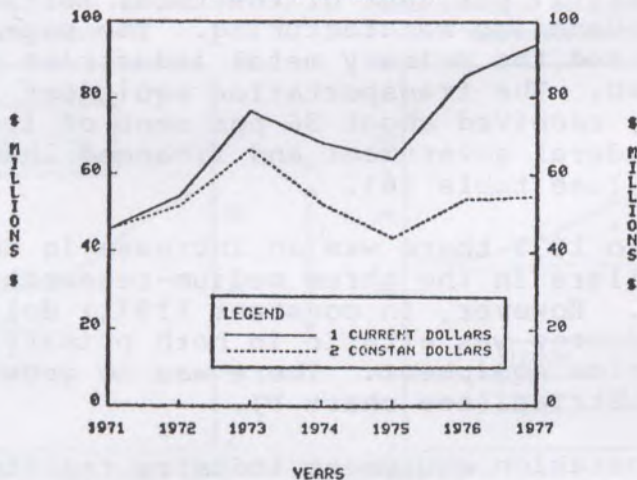
TOTAL INTRAMURAL R&D EXPENDITURES FOR 1971 -77  
PAPER & ALLIED INDUSTRIES



TOTAL INTRAMURAL R&D EXPENDITURES FOR 1971 -77  
PRIMARY METAL INDUSTRIES



TOTAL INTRAMURAL R&D EXPENDITURES FOR 1971 -77  
TRANSPORTATION EQUIPMENT



SOURCE: STATISTICS CANADA: CAT 13-003

TABLE 16

Research & Development Expenditures, 1975  
Medium-Research-Intensive Industries  
(\$ Millions)

	R&D \$ Millions	% Distribution of Sources of Funds			
		Industry	Federal Gov't.	Foreign	Total
Paper & Allied Inds.	27.1	89.7	6.3	4.0	100
Primary Metal Inds.	63.0	93.4	2.4	4.2	100
Transportation Equip.	64.0	57.0	36.1	6.9	100
	<u>154.1</u>				
% of total intramural R&D in Canadian Manufacturing	26.9				

Source: Statistics Canada

TABLE 17

AVERAGE ANNUAL RATES OF GROWTH  
MEDIUM-RESEARCH-INTENSIVE INDUSTRIES  
1961 - 1974

	Employment	Real Output	Productivity	Prices
Paper & Allied Industries	1.99	4.68	2.85	1.45
Primary Metal Industries	2.10	5.00	2.74	2.87
Transportation Equipment	3.90	9.92	6.36	0.88
Total M.R.I. Industries	2.75	6.60	3.95	1.64

Source: Based on data from Statistics Canada



## V CONCLUSION

The above results clearly demonstrate that industries which do research and development have a better track record (in terms of the four economic indicators) than those industries which do little or no R&D. Similar studies which have been done in the United States have also concluded that research-intensive or "technology-intensive" industries outperform low-technology industries <sup>8/</sup>.

Although there are many other factors which contribute to the economic health of the manufacturing sector and the economy generally, R&D and indeed the whole innovation process are crucial factors in achieving improved economic performance leading to such national economic goals as a higher standard of living, high levels of employment, and stable prices. However, Canada's research and development effort has been declining steadily over the last few years, the consequences of which may be felt over the next decade or so. R&D by its very nature is best viewed as an investment which has an expected pay-off mainly in the longer run. Thus, a declining R&D base may further aggravate the current lacklustre performance of Canadian manufacturing industries, and result in further weakening of industrial competitiveness over the longer run.

As the above analysis has shown, the seven R&D performing industries account for close to 90 per cent of the scientists and technologists engaged in R&D in Canadian manufacturing. With Canada's labour force, particularly the new entrants, becoming increasingly more educated and skill intensive, the onus of creating challenging new job opportunities will lie more and more with the R&D intensive industries.

<sup>8/</sup> See for example, M. Boretsky, "U.S. Technology: Trends and Policy Issues" Monography 17, George Washington University, Washington, D.C., October, 1973 and "The Impact of Research and Development on Long Term Economic Growth" by Dr. Thomas Vanderslice, Vice-President, General Electric Company, Fairfield, Connecticut. Paper presented at the Conference on R&D, Strategy for Success, sponsored by the Financial Post, January 1978, Ottawa.

