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RESEARCH AND DEVELOPMENT IN CANADIAN MANUFACTURING INDUSTRIES

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RESEARCH AND DEVELOPMENT IN CANADIAN MANUFACTURING INDUSTRIES

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I Introduction

It is now generally accepted that technology and technological innovation plays 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 tech-

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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".

nological change is not the only factor which effects 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, improved management techniques, etc. 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/].

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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 are assessed in terms of employment, output, productivity and price movements over the 1961 to 1974 time period[3/].

Section II of the paper presents an overview of research and development in Canadian manufacturing industries and compares the prevailing situation to those of other

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3/ 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.

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.

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II RESEARCH AND DEVELOPMENT IN CANADIAN MANUFACTURING: 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.

Manufacturing industries generally account for over 80 percent of total intramural research and development[4/] performed by Canadian Business Enterprises. (See Table 1, Page 6.) Primary industries (mines, oil and gas wells) perform about six percent of R&D and service industries (transportation, public utilities, and consultants) perform about ten percent 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

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4/ 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 percent of total intramural R&D.

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, has been declining since 1971 when the ratio was 0.43 percent. By 1977, 0.33 percent of GNP was devoted to R&D in manufacturing. (See Table 2 on page 7.)

TABLE 1
TOTAL INTRAMURAL R&D EXPENDITURES, BY INDUSTRY
1971-77
CURRENT DOLLARS ($ MILLIONS)

Industry		1971	1972	1973	1974	1975	1976	1977
imary 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
anufacturing 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
ervice 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

ource: Statistics Canada

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TABLE 2
Total Intramural R&D Expenditures in
Canadian Manufacturing
($ Millions)

	R&D CURRENT $	GNP CURRENT $	R&D AS A % OF GNP	R&D[1/] 1971 $	GNP[1/] 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

[1/] GNP implicit price index is used to convert current dollars to 1971 constant dollars.

R&D By Performer and By Source of Funds

Table 3, on page 8, 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 acocunted for approximately 85 percent of all intramural R&D expenditures: Primary Metals; Machinery (excluding electrical machinery); Transportation Equipment; Electrical Products; Petroleum Products and, Chemical and Chemical Products. The electrical products industry is the largest performer of intramural R&D and accounts for about 30 percent of industrial R&D expenditures.

TABLE 3
Sources of Funds for Intramural R&D
Manufacturing Industries 1975
($ Millions)

		Canadian Sources		Foreign Sources	Total
		Industry	Federal Government [1]		
01 02	Food & Beverages and 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. [2]	10.8	2.4	0.4	13.6
	Total	460.2	68.0	43.3	571.6

Source: Statistics Canada

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

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

This concentration of industrial R&D is not unique to Canada. For instance, in the United States, six industries also accounted for over 85% 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 percent of the total intramural R&D performed in manufacturing industries. Industry sourced about 80 percent of its intramural R&D with Federal Government providing about 12 percent of the funds. Foreign sources funded about 7 percent 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

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

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 percent 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.

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.

R&D in Manufacturing by Ownership

In 1975, $521.7 million was spent on current intramural R&D in Canadian manufacturing (see Table 4, page 11). This figure does not include capital expenditures on R&D which amounted to approximately $50 million. Canadian-controlled companies and foreign-controlled

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

companies each performed approximately half of the R&D. Furthermore, about 85% of the R&D performed by foreign-controlled companies was by U.S. Controlled companies.

TABLE 4
CURRENT INTRAMURAL R&D EXPENDITURES
BY MANUFACTURING INDUSTRY & OWNERSHIP
($MILLIONS, 1975)

	Industry	Canadian Controlled Companies	Foreign Controlled Companies	Total
01 .02	Food & Beverages and 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)[1]	(269.2)[1]	521.7

Source: Statistics Canada
X Confidential
1 Totals include confidential data

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 are 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 02	Food & Beverages and Tobacco Pds.	41.8	11	Printing, Publishing Inds.	11.2
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, on page 12, 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% 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[7/].

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% of the R&D: Paper and Allied Industries; Primary Metals Industry; Machinery Industries; Transportation Equipment; Electrical Products; and, Chemical and Chemical Products.

TABLE 6
Relative R&D Performance: Canadian-Controlled and Foreign-Controlled Manufacturing Industries

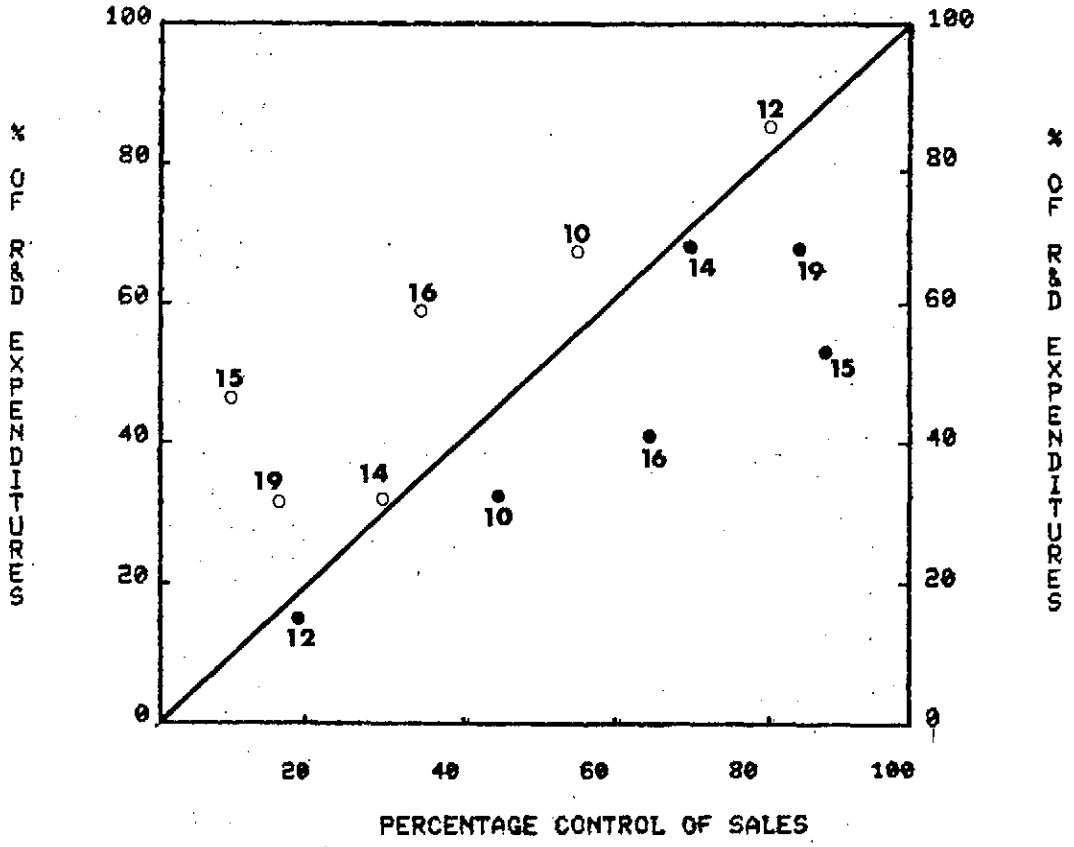
	Industry	Canadian-Controlled		Foreign-Controlled	
		% Sales	% R&D	% Sales	% R&D
10	Paper & Allied Pds.	54.7	67.2	45.3	32.8
12	Primary Metals	81.1	86.0	18.9	14.0
14	Machinery Inds.	30.7	31.4	69.7	68.6
15	Transportation Equipment	11.1	45.1	88.9	54.9
16	Electrical Products	34.6	59.2	65.4	40.8
19	Chemical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

Source: Based on data from Statistics Canada

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

CHART I

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



○ CANADIAN CONTROLLED
● FOREIGN CONTROLLED

10- PAPER & ALLIED PRODUCTS	15- TRANSPORTATION EQUIPMENT
12- PRIMARY METALS	16- ELECTRICAL PRODUCTS
14- MACHINERY INDUSTRIES	19- CHEMICAL & CHEMICAL PRODUCTS

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As can be seen from the table and the chart in every industry the R&D expenditures of Canadian-controlled companies relative to their level of sales were higher than 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.

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, page 16). Of this total, approximately 40% consisted of professional scientists and engineers, with technicians and other supporting staff accounting for 60% of the total R&D personnel.

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

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TABLE 7
NUMBER OF PERSONS ENGAGED IN R&D
IN CANADIAN MANUFACTURING
(FULL-TIME EQUIVALENTS - 1975)

	Industry	Professional Staff 1/	Supporting Staff 2/	Total Personnel
01 .02	Food & Beverages and 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. 3/	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.

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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.

Whilst Canada currently devotes less than 1 percent of its GNP on 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 percent 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 percent of the GNP. For example, the United States devotes over 1.5 percent of its GNP to R&D in manufacturing sector and, although Italy also devotes about 1 percent of its GNP to R&D, the manufacturing sector accounts for about half of the total R&D expenditures. (See Chart II, on page 18.)

Table 8 presents a summary of intramural R&D expenditures in manufacturing industries for the major OECD countries. In Canada, approximately one-third of the total

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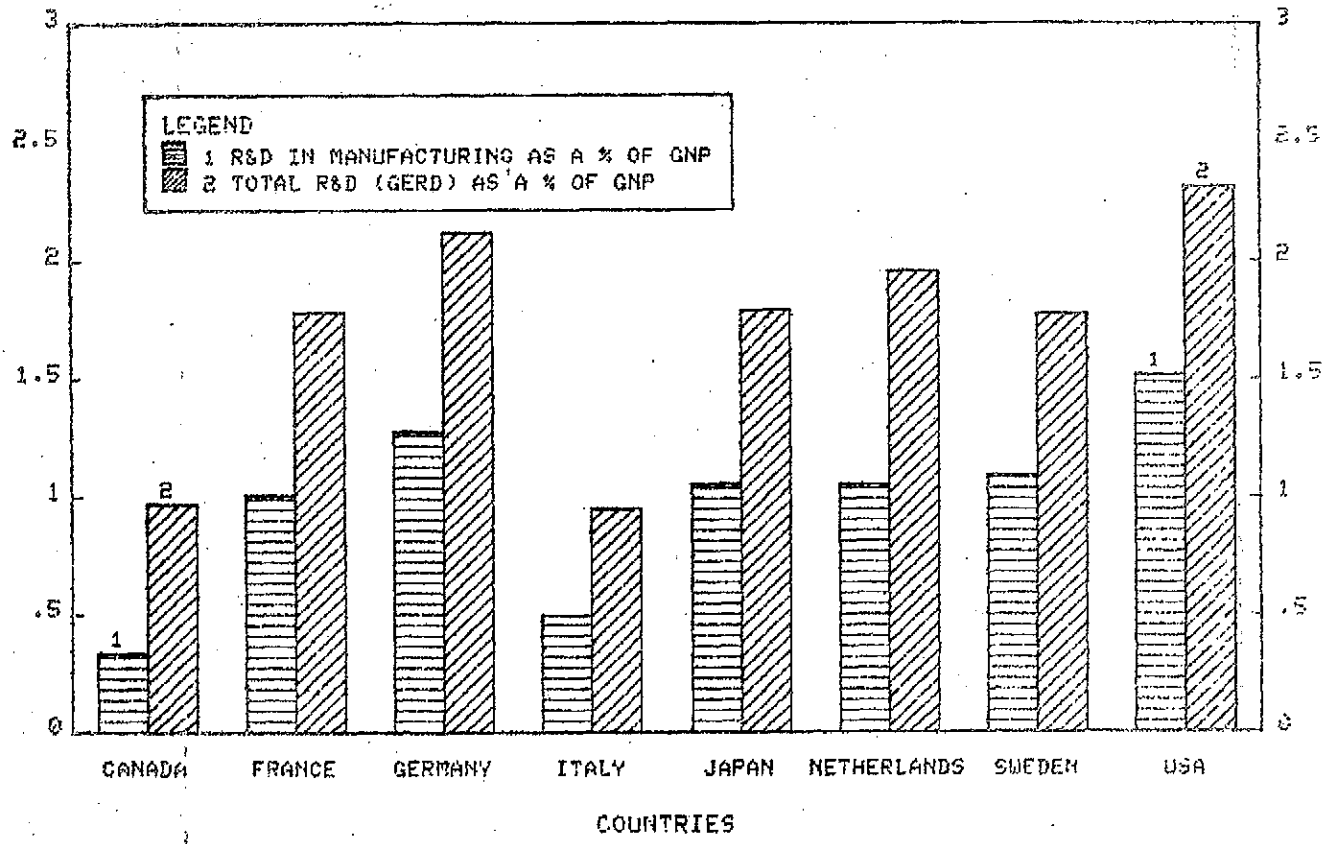
CHART II

R&D AS PERCENT OF GNP

1975



SOURCE : OECD

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R&D expenditures by all sectors is performed in the manufacturing sector. However, in most OECD countries, more than 50 percent 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 percent of its intramural R&D. In Japan, industry finances 98 percent of its intramural R&D whereas in the United Kingdom and the United States industry finances approximately 63 percent of R&D. Government is an important source of funds in France, the U.K. and the U.S. and provides for over 25 percent of the R&D performed.

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				
		Industry	Gov't.	Other National Sources	Foreign	Total
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

III Classification of Industries by Levels of Research Intensity

Although the definition of a research-intensive industry is imprecise at best, most studies in determining which industries are research-intensive use one or more of the following indexes for classifying industries: 1) R&D expenditures as a percent of shipments or value-added; 2) the number of R&D personnel engaged as a proportion of the total employment in an industry; and, 3) overall 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 percent of value-added was used to determine a research-intensive index instead of R&D expenditures as a percent of shipments. As industries purchase inputs from other industries which may embody technological advances R&D expenditures as a percent of value-added gives 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, on page 21, shows the measures of research and development intensity by industry at the two-digit SIC

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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

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level. As can be seen from the table the rankings of the industry either by R&D expenditures as a percent of value-added or by R&D personnel as a percent 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&DTE is less than 0.75; and,

4) Industries which perform no R&D.

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 Chemical & Chemical Products;

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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% of total intramural R&D performed by Canadian manufacturing and for 87% of the total personnel engaged in R&D.

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IV The Results

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% of total employment in manufacturing industries and by 1974 the share had increased to approximately 18% (see Table 10). Similarly, medium-research-intensive industries increased their share of employment from 21.3% in 1961 to 23.8% 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	319.6
	%	16.2	17.9
Medium-Research Intensive Industries		287.6	425.3
	%	21.3	23.8
Low-Research Intensive Industries		568.0	729.6
	%	42.0	40.9
Industries which perform no R&D		277.5	311.1
	%	20.5	17.4
Total Manufacturing		1,352.6	1,786.0
	%	100.0	100.0

Source: Statistics Canada

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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 percent. Employment in medium-research-intensive industries increased by over 137 thousand (47.8%) during the same time period. On the other hand, although employment in low-research-intensive industries increased by over 161 thousand, the percentage increase was about 28%. Employment in industries which performed no research and development increased by 33 thousand or 12% 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% of total output in manufacturing industries (see Table 11, on page 26). 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 low-research-intensive industries and industries which performed no R&D (see Table 12, page 26).

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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 shows 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 clearly out-performs low-research and no-research industries in each of the four indicators.

TABLE 13
AVERAGE ANNUAL RATES OF GROWTH
1961 - 1974
PERCENT

	Employment	Real[1] Output	Productivity[2]	Prices[3]
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

1 1971 Dollars

2 Real Output Per Person

3 Value-added implicit price index

Source: Based on data from Statistics Canada

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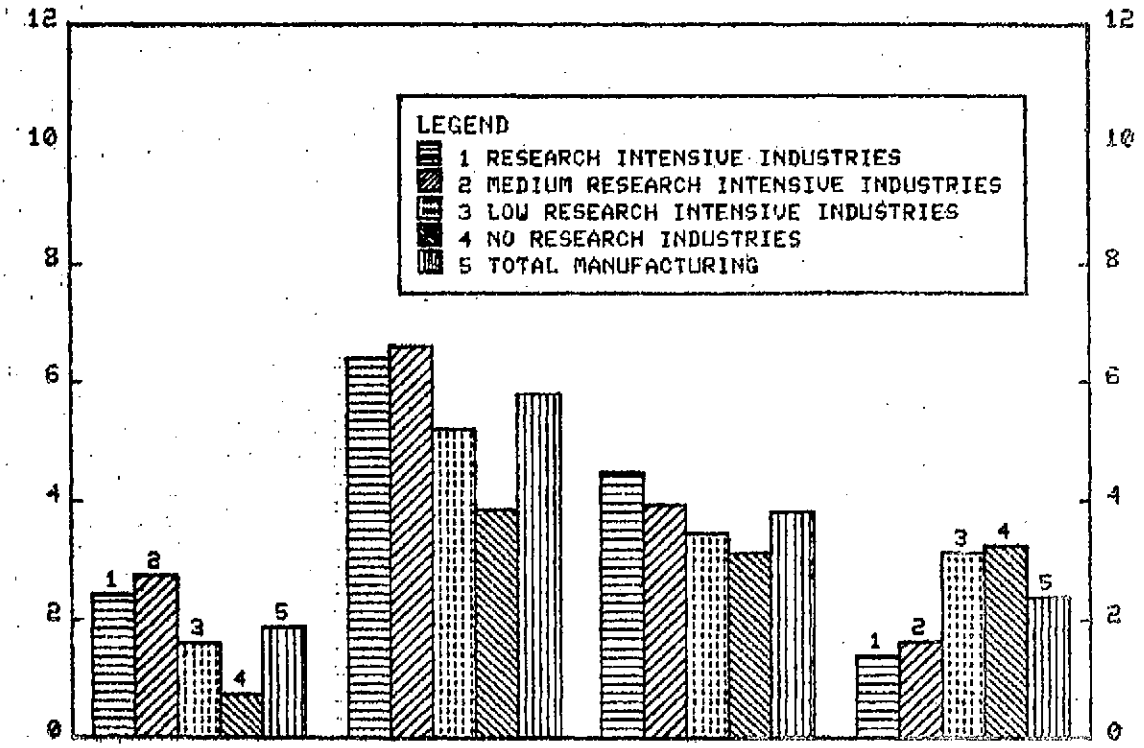
CHART III

AVERAGE ANNUAL RATES OF GROWTH

1961 - 1974



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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 1961-74 period: 1) 50.3% higher growth in employment; 2) 23.5% higher growth in output; 3) 29.4% higher growth in productivity and, 4) 55.6% lower growth in prices.

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

Medium-research-intensive industries outperformed low-research intensive industries by registering over the 1961-74 period: 1) 70.8% higher growth in employment; 2) 27.2% higher growth in output; 3) 13.8% higher growth in productivity; and, 4) 27.6% lower growth in prices.

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

The Performance of Research-Intensive Industries

In 1975 research-intensive industries spent over $350 million on R&D and accounted for more than 61 percent of the total intramural R&D performed in Canadian manufacturing industries (see table 14 on page 32).

In terms of financing, the electrical, petroleum and chemical industries sourced over 80 percent of their R&D, whereas the machinery industry sourced 64 percent of its R&D. The Federal Government provided about 12½ percent 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 percent 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, page 32). However, in

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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 percent) 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 on page 32.)

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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

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

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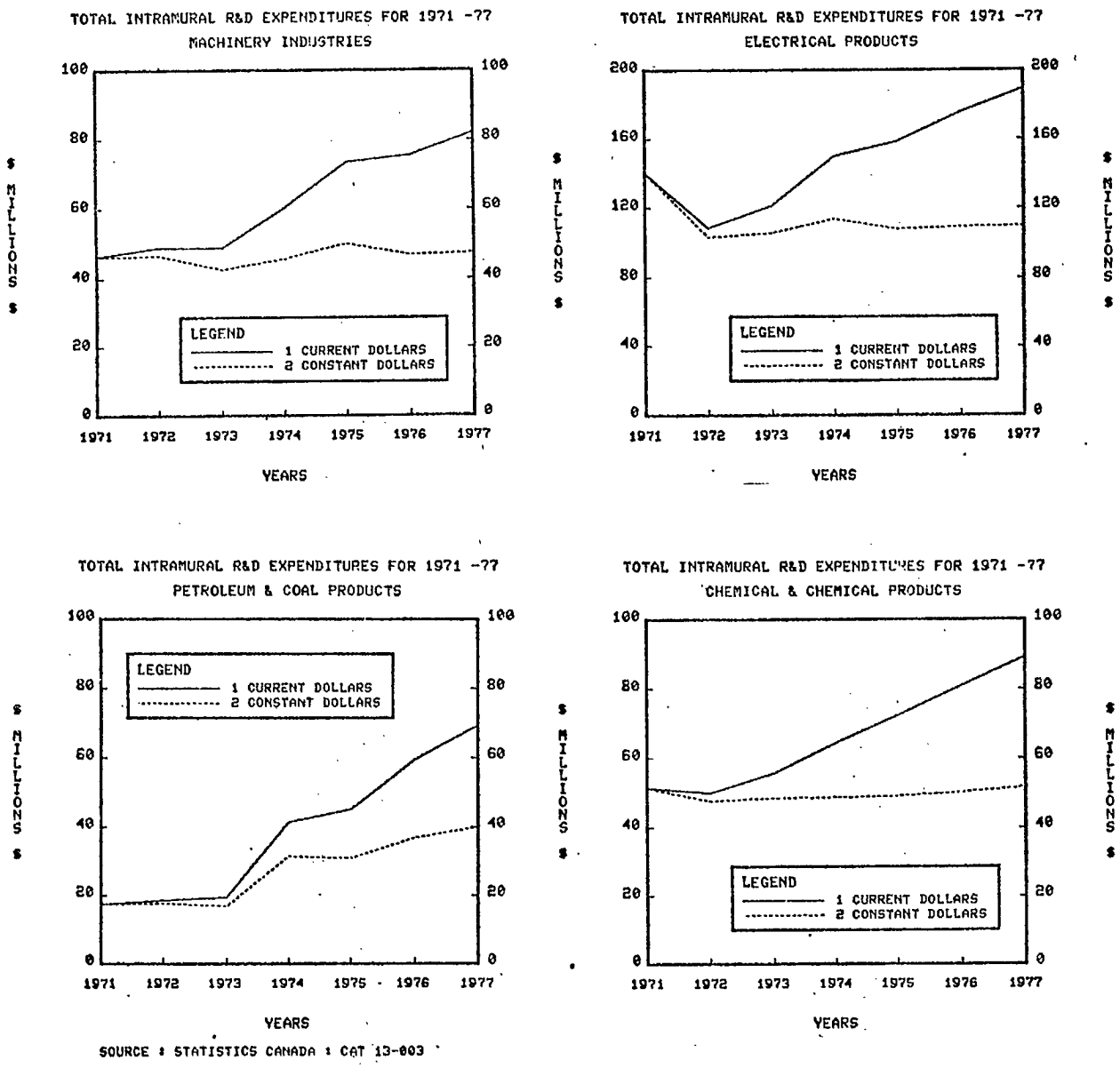
CHART IV

R&D Expenditures in Research-Intensive Industries



SOURCE : STATISTICS CANADA : CAT 13-003

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The Performance of Medium-Research-Intensive Industries

Medium-research-intensive industries accounted for approximately 27 percent 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 percent of its funds for R&D from the Federal Government and financed less than 60 percent internally. (See Table 16, page 35.)

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, page 36.)

The transportation equipment industry registered the highest rate of growth in employment (2.75 percent), output (6.6 percent), productivity (3.95 percent) and also registered the lowest rate of increase in prices (0.88 percent) over the 1961-1974 period. (See Table 17, page 35.)

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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
	154.1				
% 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

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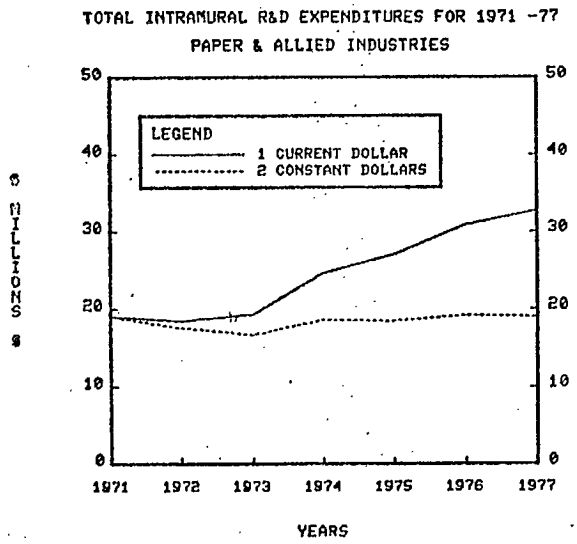
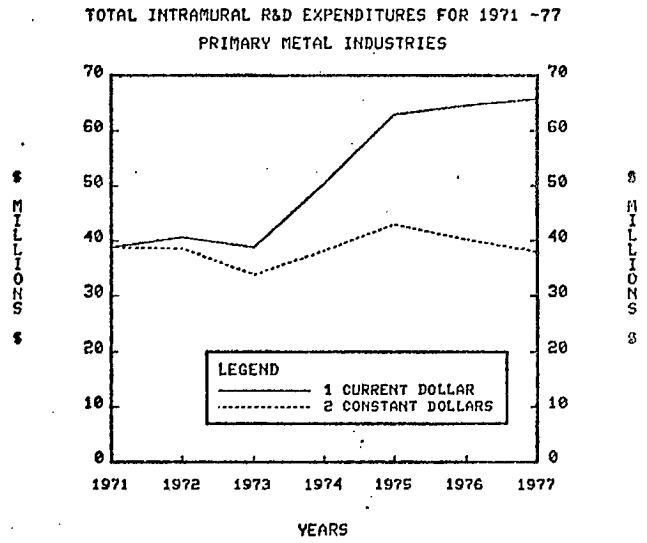
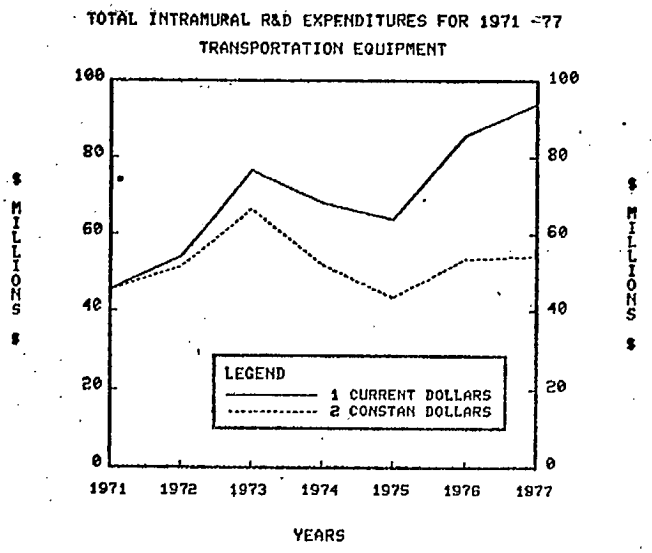
CHART V

R&D Expenditures in Medium-Research-Intensive Industries







SOURCE : STATISTICS CANADA : CAT 13-003

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V Conclusions

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[8/].

Although there are many other factors which contribute to the overall economic health of the manufacturing sector and the economy generally, R&D and indeed the whole innovation process is a crucial factor in achieving improved economic performance leading to national economic goals such 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

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8/ See for example, M. Boretsky, "U.S. Technology: Trends and Policy Issues" Monograph 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.

which has an expected pay-off mainly in the longer run. Thus a declining R&D base may further aggravate the current lack-lustre 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% of the scientists and technologists engaged in R&D in Canadian manufacturing. With Canada's labour force, particularly amongst 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.