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Innovation and the Structure of Canadian Industry

by Pierre L. Bourgault

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Dr. Bourgault received his B.A. degree in 1950 from the University of Ottawa (College Mathieu), and his B.Sc. in 1953. In 1955, after having completed course requirements for the M.A. in Education, he entered the University of Ottawa's Graduate Programme in Electrochemistry, obtaining the Ph.D. degree (Summa Cum Laude) in 1961.

In 1960 he was employed as a researcher by Johnson, Matthey and Mallory in Toronto, where he became director of the laboratory as it developed. In 1965, he became responsible for Research and Development, Engineering and Quality Control for the Electronic Components Division. In 1967, he became Divisional Manager, a post involving full responsibility for the operations of the division.

In 1969, Dr. Bourgault joined the Science Council of Canada as a Science Adviser, a position which he held until 1971. Dr. Bourgault is a Fellow of the Chemical Institute of Canada, of la Corporation des Ingénieurs du Québec and of the Association of Professional Engineers of Ontario.

He holds many patents, several of which are commercially exploited. He is the author of a number of papers in the field of electrochemistry.

Foreword

This study deals with the role of the Canadian manufacturing industry vis-à-vis the innovation process. It was prepared by Dr. Pierre Bourgault for the Science Council Committee on Industrial Research and Innovation. As a companion to Dr. A.J. Cordell's study on *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy**, this study is one of the major sources of information for Science Council Report No. 15, *Innovation in a Cold Climate*. Other background studies are to follow.

At the time that Dr. Bourgault collected the information on which this report is based, he was a Science Adviser on the staff of the Science Council. Most of the writing of the text took place after his appointment as Dean of Applied Science at the University of Sherbrooke.

The study examines the importance of science, technology and the entire innovation process to Canadian industry, together with the effectiveness of Canadian industry in using scientific and technological knowledge. It also looks at the principal factors embedded in Canadian industry which most impede innovation and the ability to use science and technology to best effect.

As with all background studies published by the Council, this report represents the views of the author, which are not necessarily the views of the Council. The Council is publishing this report because it thinks it makes an important contribution to our understanding in this area.

We are most grateful for the wholehearted cooperation of those industries which were contacted during the study.

P.D. McTaggart-Cowan,
Executive Director,
Science Council of Canada.

July 1972.

*A.J. Cordell. *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy*. Science Council of Canada Special Study No. 22. Information Canada, Ottawa, 1971.

Acknowledgements

While this report was written by a single author, who accepts full responsibility for any errors or omissions that it may contain, many persons have contributed to the ideas and the data that support it. As author of the report, I wish to acknowledge my indebtedness to these people.

My first thanks go to the many busy executives, of industry, of industry associations and of government departments, who took time to discuss with us the problems associated with innovation in the industrial sector in Canada. The insights which they provided were of utmost importance in permitting us to better understand the issues involved.

Important contributions to this report have also come from several members of the Science Council Staff who were involved in the broader Industry Study, of which this report is a part. In particular, I wish to express my thanks to Dr. Richard Armstrong (now with CIL) Dr. Arthur Cordell, Dr. Frank Kelly and Mr. Andrew Wilson, with whom I had many very valuable exchanges of ideas during the course of the Study. Thanks also to Dr. Don Bennett, Dr. Ray Jackson, Mr. Jim Mullin and Dr. Dixon Thompson, of the Science Council Staff, and to Dr. Sydney Wagner, Director General of the Office of Science and Technology, Department of Industry, Trade and Commerce, for constructive criticisms on the text.

The preparation of this report required that a large amount of statistical information be sought out, processed and tabulated. In this, I was very ably assisted at various stages in the work by Mrs. Paula Smith, Miss Claudia Krawchuck and Mr. Gerry Finn. The initiative and skill which they displayed in seeking out the data upon which much of the report rests is gratefully acknowledged.

I also wish to extend sincere thanks to my secretary, Mrs. Colette Allard, who was responsible for typing the major portion of this report in its several drafts, to Miss Florence Wark for vital secretarial assistance during the earlier part of the work, and to Mrs. Renée Grimard for assistance in typing.

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I. Introduction

Framework for the Study

In the autumn of 1969, a Committee of the Science Council was formed to oversee a series of studies whose purpose was "to inquire into matters associated with the generation and application of science and technology as they relate to primary, secondary and service sectors of Canadian industry". Among its tasks, the Committee undertook:

a) to examine the structure of Canadian industries and its effects on the innovative process;

b) to inquire into impediments and incentives to innovative activities in Canadian industry as they might arise from the public sector or from the private sector.

Impediments to innovation which have their roots within the private sector itself are likely to be associated with the structure of industry. Thus, question (a) and the second portion, at least, of (b) are closely interrelated; they might even be different formulations of the same question. The present work is one of a series of background studies on this general subject being sponsored by the Science Council.[1]

The purpose of the present report is to give a broad view of the generation and application of science and technology in Canadian industry. In particular, it will attempt to answer the questions:

- How important are science, technology and innovation to Canadian industry?
- How effectively is Canadian industry now using science and technology?
- What are the principal factors, in the environment surrounding industry and within its own structure, that most impede innovation and industry's ability to make the best use of science and technology?

The decision to give this report such a broad perspective does, of course, place limitations on the depth to which the analysis can be carried on any given point. The result then can be only a general diagnosis, to which many exceptions will exist and from which many significant points, relating to particular industry sectors, will be omitted. The reader may also find that many questions are only partially answered and some are not answered at all.

The sources of information for the study included the following:

- interviews and questionnaires taken from 50 companies selected as representative of Canadian industry
- interviews with 10 head offices of companies in the U.S., the U.K. and Continental Europe who had Canadian subsidiaries in the original group of 50.

[1]Four background study reports in this series have already been published:

A.H. Wilson, *Background to Invention*, Science Council of Canada, Special Study No. 11, Queen's Printer, Ottawa, 1970.

A.H. Wilson, *Research Councils in the Provinces: a Canadian Resource*, Science Council of Canada, Special Study No. 19, Information Canada, Ottawa, 1971.

F.J. Kelly, *Prospects for Scientists and Engineers in Canada*, Science Council of Canada, Special Study No. 20, Information Canada, Ottawa, 1971.

A.J. Cordell, *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy*, Science Council of Canada, Special Study No. 22, Information Canada, Ottawa, 1971.

In addition, meetings and discussions were held with representatives of the following:

– most of the Federal government departments and agencies concerned with innovation and industrial development;

– representatives of U.K., French and Belgian governments concerned with these questions;

– a variety of persons at the Organisation for Economic Cooperation and Development (OECD) and the European Economic Community (EEC);

– researchers in Universities in England, Scotland, France and Switzerland interested in science policy as it relates to the industrial sector;

– representatives of a number of industry associations.

The report draws most heavily on the company interviews for its source of ideas, but unfortunately these did not prove to be good sources of documentation. The first problem was that the sample was too small to have sufficient statistical significance, particularly when one takes into account the structure of Canadian industry. The differences in the way companies are structured and operated from one sector to another are so great that aggregate statistics grouping sectors would have little meaning. Even within sectors, the differences among sub-sectors make aggregation of limited value. For example, a home appliance manufacturer, a home entertainment equipment manufacturer, a telecommunications equipment manufacturer, a manufacturer of micro-circuits and a manufacturer of hydro-electric generators have relatively little in common, although they all belong in the Electrical/Electronics sector. The same can be said for manufacturers of pharmaceuticals, industrial chemicals, and paints and fertilizers, who all belong in the Chemical sector. A second difficulty which limits the usefulness of data gathered in interviews and questionnaires is the reluctance of most companies to be quoted. Obtaining information that permitted us to better understand the issues and problems, and obtaining information that could be published, were two very different problems.

Because of these limitations, the author has had to turn to conventional sources – Information Canada, OECD, United Nations Statistics, Industry Associations and like sources – for most of the supporting statistics. The examples cited in the text are also, for the most part, taken from sources other than the information obtained in interviews, although in some cases they parallel very closely examples quoted by persons interviewed.

The rationale underlying the selection of the 50 companies and their distribution by sector, by residence of ownership and by size has been given in detail elsewhere[2], and therefore will not be repeated here. The interviews themselves had two principal aspects. In part, the interview took the form of a consultation, in which the views of the executives were sought on the important issues under study (e.g., the present state and future prospects for science-based industry in Canada, the climate and opportunity for technological innovation, the impediments to more effective use of science and technology in industry, and suggestions for actions that could be taken by governments to improve the situation). The second

[2]A.J. Cordell, *op. cit.*

aspect of the interview was an attempt on our part to better understand the structure of the company and how it functioned, particularly with regard to science, technology and innovation. In this way, we hoped to develop an overall understanding of science-based industry in Canada, of *how* and *why* Canadian industry uses science and technology to produce new or improved products and processes, and of the important impediments to, and inducements for, innovation.

Perspective for Analysis

The present report is not a summary of the views expressed by persons interviewed, nor is it a description of what was observed. Rather, it is an attempt to analyze the information gathered from these sources and to give a coherent picture of science and technology in Canadian manufacturing industry, of its importance, of its use and of the factors that assist or impede its most effective use.

Despite all the care that may be taken to achieve objectivity, such a report will necessarily be affected by the author's own background and training. After all, we can see only through the eyes we have and from the vantage point at which we stand. Economic training and an academic background have been most common in persons delving into this subject. The present author's training was in the natural sciences, and his experience mostly in the industrial sector. For these reasons, then, the perspective of the present report may be expected to differ somewhat from that of other reports that have appeared on the subject. The reader will no doubt find much more importance accorded to the *non-R & D* technical and scientific activities of industry than is usual. In the author's view, these activities have been very much neglected, if not entirely overlooked, in studies of this type. They also have been, and continue to be, given insufficient attention in the formulation of policies for industrial development.

Five to ten years ago, the emphasis was almost exclusively on "Research and Development". More recently, the importance of "marketing" has been recognized. However, we continue to neglect product engineering, product design, production engineering, quality control and the other science-related non-R & D activities that are necessary to convert an invention into a product that can be marketed. These engineering activities are doubly important, not only because they are vital to the success of the product itself, but also because they have a profound influence on the suppliers of materials and parts and the suppliers of production machines and tools.

The general question of the merits of generating one's own technology versus importing technology from foreign sources is one that has been surrounded by much confused thinking. Much of that confusion is due to an overall lack of understanding of how, in specific terms, industry uses science and technology, and of what is the role that is played by product engineering, product design, production engineering, etc. As a result, many overly simplistic assumptions have been made in this area, and some of them have become the bases of policies that affect industry in Canada. This issue is of course closely related to the debate on foreign ownership.

While it is not possible in a report such as this to give a detailed account of how technology is used in industry, a few brief comments at this time might facilitate the understanding of a number of points made later.

Except in the cases of extremely simple products, or back-yard garage operations, the technology that underlies a product and the processes involved in making it are embodied in a large number of engineering drawings and specifications. The actual number can range from a few dozen to many thousands, depending upon the complexity of the product. The day-to-day application of technology on the factory floor, in the quality control laboratory, in the purchasing office, etc., is done from these drawings and specifications. Engineering drawings and specifications will be made to describe the product itself with great precision and in great detail, including its performance and its characteristics under many sets of conditions; other specifications and drawings will be made to describe, again in minute detail, all of the materials and parts that must be used in making the product; still others will describe very precisely all of the operations and conditions that must be applied to the materials and/or parts so that they become transformed into the product; still others may describe, sometimes to the point of naming the supplier and model number, the production machines and tools that must be used.

Thus, when the drawing and specifications for a product are adopted and "fixed", many things cease to be variable: it is implied that the product's properties, quality level and approximate cost are determined; likewise, the potential suppliers of materials and parts, and of production machines and tools, will have been restricted (or in some cases specifically determined); the extent to which the process is to be capital- or labour-intensive, and the skills required for manufacturing, will have been determined; decisions regarding the environmental impact of the operation will have been made; and so on.

Underpinning these product, material and production specifications and drawings, there will be a considerable amount of specialized engineering know-how, experience and design data. These must be used to generate the drawings and specifications, but they are not available from them. This "underpinning" technology is by nature more general and widely applicable but it is not sufficiently specific to be used directly. Often, this second-tier technology will in turn be based on more fundamental, and consequently less specific, knowledge.

When discussing technology transfer, it is important that we distinguish the form in which it is transferred, as this will have important consequences on the benefits that can be derived from it. Many forms of transfer are possible. The simplest, and often least beneficial, method is to transfer it in its fully embodied form; this is what happens, for example, when we import an entirely new machine that makes for more efficient production or when we import a new plastic for a given application. Another way of getting the machine is to obtain detailed drawings and specifications of it, which can be given to a machinist or toolmaker so that he can build it; but if the machine is at all complex, it will in all probability be necessary to buy at least some of the materials or parts from the original source in order to be sure the machine will work. A third way is to hire an engineer who has a good understanding of that general type of machine, and to obtain from the original designer the essential specific information and design data which he used to develop his design; this will give more flexibility in building a machine for a particular need, and also more flexibility in the materials used.

Given a team of engineers whose combined expertise covers a broad spectrum of knowledge, instead of one with only a general knowledge of that field, it would be possible to get by with less information and with information of a more general nature. For example, instead of having to know the type of stainless steel required for a given part, it may be sufficient to know the corrosion resistance requirement. This further increases flexibility, both in modifying the design to best suit the needs and regarding the choice of sources of supply for greatest economy.

On the other hand, of course, a manufacturer may not be able to afford a team of engineers, or one engineer, or even the services of a machinist. That would depend upon the number of machines needed and the use to be made of them.

However, two things are certain: the depth to which a firm can receive the technology pertaining to a machine will depend upon which of the above situations applies; and the chances of improving on that machine the next time one is needed will be much better following participation in the development, engineering and development of the first one.

It is not easy for a company to determine what level of technological capability it should maintain for generating its own technology and for adapting the technology it receives from abroad. Moreover, because the actions of each company affect the industrial environment of the nation, the economically optimum level from the company's point of view may not correspond to the optimum level from the nation's.

These problems are not simple, nor are the answers clear, but, as we are the industrial nation which puts probably the greatest reliance on the technology of others, it is extremely important that we lead the way in understanding the issues and in seeking answers to them.

II. Science-Based Industry, Innovation and National Goals

Concepts and Definitions

The names "science-based industry" and "high-technology industry" are used more or less interchangeably to describe those industries in which science and technology play a key role. If one considers the employment profile for the different manufacturing categories, one finds that the majority of scientists and engineers are employed within relatively few industry groups. This can be seen from Table II.1, which shows that in 1961 the electrical products, chemicals and transportation equipment industries were responsible for employing nearly one-half of all scientists and engineers employed by industry in Canada.

Table II.1–Employment in Canadian Manufacturing Industries, 1961[a]

Industry	Total Scientists and Engineers	Total Professional Employment	Scientists and Engineers as a % of Total Employment
Electrical Products	3 903	10 683	4.3
Chemicals & Chemical Products	3 209	7 730	5.1
Transportation Equipment	2 736	7 454	2.7
Primary Metal	2 071	5 329	2.3
Paper & Allied	1 583	5 550	1.6
Metal Fabricating	1 463	4 960	1.5
Machinery	1 331	3 906	2.6
Petroleum & Coal	1 136	2 741	7.1
Food & Beverages	1 075	3 667	0.5
Non-metallic Mineral Products	569	1 587	1.3
Textiles	494	1 712	0.8
Rubber	193	739	0.9
Wood	142	834	0.2
Printing, Publishing & Allied	34	5 980	0.04
Furniture & Fixtures	30	436	0.1
Miscellaneous[b]	1 318	5 548	2.5

Notes: [a]These data are obtained only every ten years and the corresponding figures for 1971 were not available from Information Canada at the time of printing.
[b]Caution should be exercised not to regard this as a residual to include all other industries.
Source: DBS. "Labour Force Occupation by Industries". Cat. 94-552.

These, then, are the principal "science-based" or "high-technology" industries. It is also notable that these industries employ large numbers of other types of professionals and highly trained persons. They could therefore equally well be called the "knowledge industries".

As one might expect, these industries are also the ones that do the most research and development. Table II.2 shows the distribution of research and development expenditures for several OECD countries. It can be seen from this table that the three aforementioned industries account for about two-thirds of the total R & D expenditure in most of the countries.

It should be noted, however, that there are very large differences in science intensity among various sub-groups within any particular industry group. For example, within the chemical industry the sub-group of pharmaceuticals is more science-intensive than fertilizers, and within the electronics industry the components sub-group is more dependent on science and technology than is home entertainment equipment. It is also

Table II.2–The Structure of R & D Expenditure in Manufacturing Industry (In percentage of total manufacturing industry)

Country	Year	Science-Based				Mechanical				Other			**Total**
		Aircraft	Electrical	Chemical	*Total*	Machinery	Basic Metals	Other Transport Equipment	*Total*	Allied Products	Miscellaneous Products	*Total*	
United States	1963-64	38.3	24.8	13.0	*76.1*	8.0	2.6	8.9	*19.5*	2.5	1.9	*4.4*	**100.0**
France	1964	24.6	28.6	19.4	*72.6*	7.6	5.3	5.8	*18.8*	4.6	4.0	*8.6*	**100.0**
Canada	1963	16.9	29.1	23.6	*69.6*	4.2	9.8	0.9	*14.9*	5.4	10.1	*15.5*	**100.0**
United Kingdom	1964-65	29.0	24.5	14.4	*67.9*	8.4	8.7	7.3	*21.4*	6.7	4.0	*10.7*	**100.0**
Germany	1964	b)	31.2	34.7	*65.9*	19.6	8.4	b)	*28.0*	4.7	1.4	*6.1*	**100.0**
Belgium	1963	1.5	20.3	43.8	*65.6*	5.0	18.1	0.6	*23.7*	3.7	7.0	*10.7*	**100.0**
Japan	1964	a)	30.3	27.3	*57.6*	5.1	9.4	11.3	*25.8*	8.4	8.2	*16.6*	**100.0**
Sweden	1964	19.8	24.3	9.9	*54.0*	13.9	13.1	7.8	*34.8*	4.1	7.1	*11.2*	**100.0**
Italy	1963	a)	25.7	28.1	*53.8*	10.5	5.6	20.1	*36.2*	9.1	0.9	*10.0*	**100.0**
Austria	1963	a)	18.6	24.0	*47.6*	4.0	24.9	16.3	*45.2*	4.0	3.1	*7.1*	**100.0**
Norway	1963	a)	22.0	21.3	*43.4*	6.6	23.4	5.3	*35.3*	6.1	15.3	*21.4*	**100.0**

a) Included in "other transport equipment".
b) Included in machinery
Source: OECD, *Gaps in Technology: Analytical Report*, Paris, 1970.

important to recognize that the manufacture of even the most science-intensive product usually contains many operations that in themselves have little or no technological content. This is particularly noticeable in the electronics industry, where most products have in their manufacture a number of labour-intensive operations. These operations can be performed quite separately and in different locations from the "technological" or "knowledge" portions of the operation. In this industry, it is not uncommon to find that the labour-intensive assembly operations are performed in ar Eastern or other low-labour-rate countries, while the engineering specifications and drawings, as well as some of the less labour-intensive parts, come from the more advanced industrial countries.

In the same way that all of the electronics, the chemicals and the transportation industries are not high-technology, so some sectors usually thought of as being less technology-dependent may contain some very science-intensive sub-sectors. Electronic grade metals in the metal industry, precision tubing and aircraft parts in the metal fabrication industry, and dielectric papers in the paper industry are examples of high-technology products within what we normally consider to be the less science-intensive sectors of manufacturing industry. Most, if not all, sectors of manufacturing have a certain number of products or processes that have a strong dependence on advanced technology.

Innovation

Technological innovation can be defined as the application of scientific and technological knowledge in a new way with commercial success. In the present report, innovation is considered to include all of the steps from research, through development, product or process engineering and marketing, to the point of commercialization. Many associate very closely, or even tend to equate, R & D with innovation. In fact, R & D to the point of basic invention constitutes but a relatively short distance along that long and hazardous path, from concept to marketplace, which we call the innovative process. A panel of experts, chartered by the U.S. Department of Commerce to study ways of improving the environment for innovation, estimated that research and advanced development account for between 5 and 10 per cent of the total cost in successful product innovations.[1] Engineering and designing the product costs about twice as much (between 10 and 20%). The most expensive portion of the process (accounting for 40 to 60% of the total cost) is production engineering and tooling. The remaining expenditures are for manufacturing start-ups and for introducing the product on the market. It would be wrong to assume that the activities beyond the point of invention involve merely the expenditure of money with little involvement of technology or of other specialized skills and knowledge. While the requirements for science and technology in the post-invention stages of the innovation process are perhaps less intensive than in the pre-invention stages, it is doubtful that the point of invention

[1]U.S. Dept. of Commerce, Chairman: Robert A. Charpie, *Technological Innovation: Its Environment and Management*, Washington, 1967.

would, in most cases, mark more than the half-way point in terms of the purely technological inputs required for innovation. Commercial manufacture of a product of even moderate complexity requires elaborately developed specifications and design drawings for the product, as well as for each component and each material incorporated into the product. It requires, in addition, the elaboration of detailed manufacturing and quality control procedures covering each of the phases of manufacture. It may also involve the design of equipment to be used in the manufacturing process. To do all this, and arrive at a commercially competitive product, requires technological capability which is at least as high as that required to generate the invention in the first place.

Contribution of Technology to the Achievement of National Objectives

In its Report No. 4[2], and later in Report No. 9[3], the Science Council of Canada enunciated a set of seven national goals which were felt to represent the principal aspirations of Canadians. They were national prosperity, health, education, freedom with security and unity, leisure and personal development, world peace and preservation of the environment. While there appears to be general agreement among Canadians on these basic goals, there are considerable differences in their interpretation and the relative degree of emphasis that should be placed on each of them. The most fundamental issue upon which many of these differences hinge is that of growth, both of population and of consumption.

Many Canadians lean toward the older established values, and believe that we must emphasize the creation of job opportunities through economic growth and that we must strive to improve individual well-being through increasing per capita income. It is argued that the material well-being of the less priviledged groups of our society has not yet attained a level at which they would readily accept a stabilization in the availability of material goods. On the other hand, an increasing number of Canadians question these conventional values, arguing that environmental deterioration and resource depletion are over-riding issues. These Canadians question the value of Gross National Product (GNP) as a measure of national progress and of per capita income as a measure of individual well-being; they question the desirability of growth itself as a national objective.

As the debate continues, there appears to be emerging a consensus that the exponential growth rate of the past century cannot be projected indefinitely into the future. The world is finite in space, in resources and in its ability to cope with the various stresses that man and his technology can create. While there is some agreement that we must alter the course we have been on, there is much less agreement on the degree and direction that this alteration should take.

[2]Science Council of Canada Report No. 4. *Towards a National Science Policy for Canada.* Queen's Printer, Ottawa, 1968.

[3]Science Council of Canada Report No. 9. *This Land is Their Land*... Queen's Printer, Ottawa, 1970.

One of the points at issue is the role that technology can and should play in shaping the world of the future. Some see technology as the principal villain in leading mankind to ecological disaster, while others see it as the saviour which alone can ward off the disaster. In fact, technology is merely a very powerful tool in the hands of man. It has been used in the past to bring great benefits to man; but in recent times, we have begun to observe some disbenefits that are no longer of negligible proportions. To a large extent the difficulties brought on by the application of technology are due to the fact that in the past we have stressed quantity rather than quality. Technology has been used to increase the output of our production lines and chemical plants, to increase our capacity to transport goods and people, to make energy, in various forms, widely available and inexpensive. It has improved the quality of life by massively increasing the through-put of resources.

We now recognize that we cannot continue indefinitely to increase the rate of resource through-put; we are limited both by the overall availability of the resources and by the rate at which the planet can assimilate the wastes generated by the high rate of their utilization. In the decades ahead we can therefore look to a change of emphasis in the application of technology, away from quantity and toward a greater concern with the quality of goods and services. Rather than seeking to produce more goods more cheaply, we will strive to produce goods that have greater reliability, durability, safety, efficiency and esthetic value; rather than striving to make more automobiles, larger automobiles and more gasoline available to transport people around the country, we will strive to develop transportation systems that require fewer tons of steel and fewer gallons of fuel to do the same job. We can no doubt continue to expect growth of the economy, but that growth will come increasingly from intellectual and artistic inputs and less from simple increases in the through-put of resources. If Canada wishes to retain its place in the world of tomorrow, she must develop the capability to perform the activities that will be important in the world of tomorrow. That world will depend more upon knowledge and less upon materials than does the world of today.

Whether one espouses the concept of zero growth, or whether one has more traditional views on these questions, it is very difficult to see how one can reject the need to develop a strong technological capability in Canada. Technological capability will give us the power to act in the world of tomorrow. It will be the sail of our ship. If we do not agree with the direction in which we are sailing, we should give different instructions to the man at the helm – or have him replaced – but surely we must not throw the sails overboard.

We must also remember that, wherever we wish to go, we must start from where we are, and then evolve. Also, while looking to the future in our global planning, we must cope with the problems of today – and we must do so with the resources at our disposal. It is therefore important that we assess very realistically our capabilities and our limitations. It is also important that we consider both the short- and the long-term consequences of the actions we take.

Technology and Employment

The problem of unemployment is one that has plagued Canada more than most other industrially advanced nations during the past decade. Among the OECD nations for which data are available, only Ireland has unemployment rates higher than Canada (See Table II.3). Canada also differs from the other industrialized members of the OECD in the relatively low percentage of persons employed in the manufacturing sector and the high percentage employed in the service sector. This can be seen by reference to Table II.4.

Table II.3–Selected Unemployment Figures[a] (Percentage of the Work Force)

Country	1969	Average (1964-1969)
Austria	2.8	2.7
Belgium	3.7	3.2
Canada	4.7	4.3
Denmark	3.9	3.0
France	1.8	1.6
Germany	0.8	1.1
Ireland	6.4	6.2
Japan	1.1	1.0
Netherlands	1.4	2.8
Norway	1.0	0.9
Spain	1.5	1.6
Sweden	1.9	1.7
U.K.	2.5	2.0
U.S.	3.5	4.1

[a]The United Nations has two measures of unemployment; one is from a labour force sample survey and the other is from the registered unemployed. In all cases except Sweden the results from only one measure (which was available) were reported. With Sweden it was arbitrarily chosen to use the first measure.
Source: The Monthly Bulletin of Statistics, United Nations, Vol. XXV, No. 3, New York, U.S.A., March 1971.

While it would be difficult to establish a cause-and-effect relationship between our high employment in the tertiary sector and the continuing high rate of unemployment in Canada, it does seem probable that the pressure of high unemployment has been a contributing factor in the disproportionate growth of the tertiary sector in our economy. The more highly motivated unemployed, unable to find work in the primary and secondary sectors, would quite naturally be inclined to turn their attention to the tertiary sector, where self-employment is likely to be the most easily achieved. In fact, the way we do our accounting, all those who are not employed in the primary and secondary sectors and who somehow find something to do get counted as being employed in the tertiary sector. While employment in the service sector is not necessarily of lower productivity or of lesser utility to society than employment in other sectors, it does seem probable that the incremental employment, due to the pressures of a high overall level of unemployment, would in fact be of low productivity and utility.

Throughout the developed nations of the world it is the manufacturing industries, along with the service industries, which have been the principal sources of new employment. The primary sector by contrast has produced

Table II.4–Selected Employment Statistics, 1969 (Percentages)

Country	Primary[a]	Secondary[b]	Tertiary[c]
Austria	20.2	29.2	50.5
Belgium	6.8	33.9	59.2
Canada	9.6	23.3	66.9
Denmark	11.8[d]	28.9	59.1
France	16.1	28.3	55.4
Germany	11.5	38.2	50.1
Ireland	29.3	20.1	50.5
Japan	19.2	26.6	54.0
Netherlands	8.1	29.2	62.6
Norway	15.2	26.3	58.3
Portugal	32.0	25.4	42.5
Spain	31.6	26.6	41.5
Sweden	9.3	29.9	60.6
U.K.	4.7	36.3	58.9
U.S.	4.6[d]	33.7[e]	61.6[f]
Total OECD	**15.3[d]**	**37.2[e]**	**47.5[f]**

[a]Primary includes agriculture, forestry, hunting & fishing, mining and quarrying
[b]Secondary includes manufacturing
[c]Tertiary includes construction, electricity, gas, water & sanitary
[d]Does not include mining and quarrying
[e]Includes mining and quarrying, construction, electricity, gas, water, sanitary services and manufacturing.
[f]Includes commerce, transport, storage, communication services and others.
Source: OECD, *Labour Force Statistics 1958-1969*, Paris, 1971.

few, if any, new jobs. Even in Canada, where the rate of investment in the primary sector has been very high, the direct impact on employment has been very small. This can be seen by reference to Table II.5.

Table II.5–Annual Average Index Numbers of Employment, by Industrial Division and Selected Groups (1961 = 100)

Industry	1965	1967	1969
Forestry	104.1	102.3	88.7
Mining (including milling)	105.1	109.0	107.9
Manufacturing	117.2	123.2	125.2
Machinery	137.1	149.7	151.4
Transportation Equipment	137.5	151.8	155.6
Electrical Products	128.1	144.2	150.4
Petroleum and Coal Products	97.2	102.7	104.0
Chemical and Chemical Products	111.1	118.8	120.4
Construction	118.4	122.5	119.1
Transportation, Communications and Other Utilities	104.8	111.0	111.9
Trade	114.3	125.8	136.6
Finance, Insurance and Real Estate	116.6	126.0	138.8
Service	125.9	153.4	171.8

Source: Canada Year Book, 1970-71, Statistics Canada. Information Canada, Ottawa, 1969.

Likewise, on a world-wide basis, the manufacturing industries have been growing in value of output much more rapidly than the primary industries, and there is little reason to expect this trend to change in the near future. On the contrary, the present concern about the environment and resource depletion will lead to increasingly efficient use of resources and to a considerable amount of recycling, thus further accentuating the discrepancy in growth rates between crude materials and manufactured products. Among manufactured products, moreover, it is those products which are most highly science- and technology-intensive that have the fastest rates of growth. This can be seen in Table II.6, which shows production indices for a number of selected industries in the United States; these are also the industries in which innovation is most frequent and most significant.

Table II.6–Production Indices for Selected Industries in the United States, 1969
(1957-1959 = 100)

Total Manufacturing	**174**
Chemicals and Products	239
Plastic Materials	468
Man-made Fibres	398
Basic Organic Chemicals	233
Soaps and Related Products	162
Paints	136
Fertilizer	132
Electronic Products	302
Computing Equipment	1 200
Semi-conductors	360
Passive Components	190
Petroleum Products	144
Paper and Paper Products	176
Textile Mill Products	154
Primary Metals	149

Sources: Chemical & Engineering News, Vol. 48, No. 37, American Chemical Society, September 7, 1970.
Electronic Industries Association (EIA), *Electronic Market Data Book 1971: Industry Sales and Trends Through 1970*, Marketing Services Dept.; Washington, 1971.

The panel on "Invention and Innovation" headed by Robert A. Charpie[4] concluded that there is a very significant relationship between innovation and economic growth. Moreover, in their report they state:

"We also thought it would be useful to compare the average annual growth of the Gross National Product over the period 1945/1965, with that of some of the companies that have committed themselves to innovation as a way of life and have experienced most of their growth over the 20 year period. We analyzed the growth histories of Polaroid, G.M., International Business Machines, Xerox and Texas Instruments. While the average annual growth rate of the GNP over this period advanced at a rate of 2.5 per cent, the average annual net sales growth of these companies ranged from 13 to 29 per cent and averaged for the group nearly 17 per cent. At the same time, the average yearly growth in jobs ranged from 7.5 per cent to almost 18 per cent."

The potential of technological innovation is further demonstrated in a Study conducted by the Sloan School of Management at the Massachusetts Institute of Technology.[5] The study covered 21 private, technologically

[4]Robert A. Charpie, *op. cit.*
[5]*Ibid.*

based ventures in the Boston area. The results of this study are summarized in Table II.7.

Table II.7–Technological Ventures and Job Creation

Number of Companies in the Study	21
Average Time Period	4.2 years
Total Increase in Sales	$76 806 000
Average Increase in Sales Per Company	$ 3 657 000
Total New Employment	3 096
Average New Employment Per Company	147
Total Venture Capital Requirements	$ 4 720 000
Average Venture Capital Per Company	$ 225 000
Average Venture Capital Per Job	$ 1 525

It can be seen from this table that the average venture capital required to create one primary new job was just over $1 525. With this modest amount of risk money, the remaining capital required could be raised from conventional sources. Although these data suffer from certain deficiencies, in particular that of being taken only from the Boston area which has been unusually fertile ground for sprouting new ventures, they do give an indication of the job-creating potential of technological ventures. When one contrasts these costs with the high cost of creating new jobs in mature industries (as much as $25 000 per job for industries like textiles which are considered not to be capital-intensive, and often more than $100 000 per job for the more capital-intensive primary sector), it is readily appreciated that the percentage of failures of new ventures would have to be high indeed in order for this not to be an effective way to generate employment opportunities. Moreover, the type of employment created would tend to be challenging and suited to the kind of educated young Canadians who will be entering the labour market in the 1970s and 1980s.

Canada is a country which has had a high rate of capital formation for many years. This has come from two sources, reinvestment of domestically generated capital, and a net inflow of foreign capital which has persisted almost without interruption from the early part of the century until very recently. Table II.8 gives a comparison of the rates of total industrial capital formation for Canada and the United States for a number of representative years.

The most plausible explanation for this high degree of capitalization in Canadian industry would, at first sight, appear to be that Canada places relatively more emphasis on the primary sector, which is generally conceded to be more capital-intensive. While this is undoubtedly a factor contributing to our high rate of capitalization, it does not entirely explain the situation. If one compares the manufacturing sectors of the two countries, one finds that in Canada the projected investment for 1970 will be in excess of $3 billion.[6] By comparison, the investment in the manufacturing industry in the United States for 1970 would be $32 billion, or a factor of about 11 greater than Canada, while the U.S. GNP is about 12 times greater. Thus, the U.S. invests a relatively smaller portion of GNP in the manufacturing

[6]Bank of Nova Scotia, *Resource and Industrial Development in Canada*, Progress Report, 1970. Quoted by Permission.

Table II.8–Intensity of Industrial Capital Investment, Canada and U.S. (Billions of Dollars)

	1956		1965		1970	
	Canada	U.S.	Canada	U.S.	Canada	U.S.
Machinery and Equipment (Producers Durable Equipment)	2.7	27.2	4.5	44.8	5.9	65.4
Non-Residential Construction (Structures)	2.6	17.8	4.0	24.9	5.3	36.8
Total Industrial Capital Formation	5.3	45.0	8.5	69.7	11.2	102.2
GNP	30.6	419.2	52.1	681.2	84.4	976.5
Share of Industrial Capital Formation in GNP	17.3%	10.7%	16.4%	10.2%	13.2%	10.4%

Sources:
Statistics Canada, *Canadian Statistical Review*, various issues.
U.S. Department of Commerce, *Survey of Current Business*, various issues.

industry than does Canada, and this despite the fact that manufacturing contributes relatively more to GNP and employs a relatively larger portion of the work force in the U.S. than it does in Canada. Even when one makes comparisons within a given industry, one finds very frequently that capital investment per job in Canada is higher than anywhere else in the world. For example, a recent OECD report on the chemical industry indicates that Canada makes the largest annual investment per person employed in that industry. This is shown in Table II.9, where it can be seen that in Canada the investment per person employed in 1967 was \$3 340, compared to \$2 910 in the U.S., \$1 980 in Japan and \$1 890 in Western Europe. The corresponding figures for 1968 were: Canada \$4 010; U.S. \$2 725; Japan \$3 195; and Western Europe \$1 795.

This high level of investment in the chemical industry is not, however, a reflection of a disproportionately large amount of the total manufacturing investment's being diverted into that industry – as can be seen again in Table II.9. In that year the chemical industry accounted for 9.7 per cent of all investments in manufacturing in Canada, compared to 10.8 per cent in the U.S. and, on the average, to a comparable percentage in Western European countries. Contrary to what one might intuitively expect, this large capital input into the Canadian chemical industry did not result in a comparable improvement in its output. This can be seen from Table II.10, which gives the increases in output for the chemical industry in various countries in 1968 and 1969.

The characteristics of high capital intensity and relatively low proportional employment in the manufacturing and chemical industries could also be indicative of high productivity. Unfortunately, this can be only a partial explanation for the Canadian facts. While the output per worker is generally higher in Canada than in Europe and Japan, it is very substantially lower than in the United States. Figures released by the OECD for the chemical industry showed that the value added per person employed in 1967 was \$9 400 in Western Europe, \$9 530 in Japan, \$15 650 in Canada and \$23 650 in the United States.

Table II.9–Investment in the Chemical Industry, by Country

Country	Investment as a % of Total Investments in Manufacturing Industries		Investment Per Person Employed in the Chemical Industry (in Dollars)	
	1967	1968	1967	1968
Belgium	19.7	21.1	1 890*	1 795*
Finland	6.2	8.2		
France	7.4	6.7		
Germany	11.4	10.3		
Italy	11.0	10.4		
Netherlands	17.5	15.8		
Norway	12.3	8.0		
Spain	4.6	6.2		
Sweden	6.1	7.2		
United Kingdom	13.3	12.9		
Canada	9.7	n.a.	3 340	4 010
United States	10.8	10.7	2 910	2 725
Japan	7.0	n.a.	1 980	3 195

Notes:
*These values are for Western Europe, excluding Austria, Denmark, Greece, Ireland, Luxembourg, Portugal, Switzerland and Turkey.
n.a. = not available.
Sources:
OECD, *The Chemical Industry 1966-67*, Paris, 1968.
OECD, *Draft Statistical Report on the Chemical Industry 1969-70*, Paris, Dec. 10, 1970.

Table II.10–Increase in Chemical Production (Percentage)

Country	1968	1969
European Member Countries	12.9	12.3
Canada	7.0 (3.7)	6.3
United States	8.8	7.4
Japan	15.8	20.6
Whole OECD Area	10.4	10.6*

*excludes Canada
Sources: OECD, *The Chemical Industry 1969-70*, Paris, 1971.
Canadian figures are obtained from *Canada Year Book, 1970-71* (Statistics Canada). Procedure used here was to calculate annual growth in Value and Shipments. The figure in brackets is the figure given by OECD in the report.

Looking to the 1980s and Beyond

Canada has long been a net importer of most categories of manufactured products. We have been paying for these with net exports in pulp and paper, minerals, primary metals, lumber, wheat and whiskey, and – until very recently – with a net inflow of foreign capital. A question we must ask ourselves is the following: Can we continue this pattern into the 1980s and beyond? While accurately forecasting our trade pattern into the 1980s would require a talent for crystal ball reading, certain considerations on this question are worthy of mention.

One of our most important net contributors to the balance of payments, and a mainstay of our economy, is the pulp and paper industry. This industry is presently in a severe slump in Canada and, while present difficulties can to a large extent be attributed to short-range factors that are likely to be transitory, there are a number of more fundamental problems that give concern for longer-term prospects. The short-term problems are primarily:

– the reduced demand for newsprint in the U.S. due to the economic downturn;

– the rise in the value of the Canadian dollar relative to the U.S. dollar;

– the over-expansion of capacity in recent years (largely with government grants);

– the pressure for, and cost of, pollution abatement.

Looking at the longer-term prospects in pulp and paper, we note first of all that the long-term trend over the past two decades has been for this industry to decline in relative importance in Canada (from 5.3% of GNP in 1950 to about 3.2% in 1970). There is little reason to believe that this trend will be reversed; on the contrary, there are several considerations which lead us to believe that the trend could accelerate. These factors are:

– the possibility of a shift toward relatively greater use of wood grown in warmer climates for making paper and paper products. This has been made possible by the development of new technologies which extend the range of application of shorter fibres. The much higher rate of reforestation in warmer climates offers distinct economic advantages;

– more recycling of pulp and paper products. This is a trend which is distinctly discernable, although quantitatively it is still too small to be felt;

– petroleum-based paper substitutes. These exist at the moment, but high costs make them a threat to only the highest grades of paper. However, their costs contain a lower labour component than does paper and, if past trends prevail, this will make them increasingly competitive with time;

– a possible long-term trend toward reducing the size of the American newspaper. If the average newspaper in the U.S. were to take on the dimensions of the average European newspaper, the impact on the Canadian newsprint industry would be quite dramatic;

– a possible reduced rate of increase in the quantity of paper used in business and communications as other means of information storage and transmittal gain prominence;

– a possible reversal in the trend toward disposable packaging as the "anti-pollution", "anti-consumption" movements gain momentum;

– the fact that pulp and paper companies in Canada, taken collectively, have reduced research and development very substantially and in a way that cannot be quickly reversed. This certainly reduces the probability of developing new applications to replace the inevitable losses. It may also indicate a loss of confidence by management in the long-term future of their industry.

Of even greater importance to our economy and to our balance of trade are the primary metals and minerals industries. Here, the situation is quite different than that of pulp and paper. The growth of the mineral industry since 1950 has exceeded the growth of GNP (6% per annum for the mineral industry, versus 4.5 for GNP – both in constant dollars). The situation differs from pulp and paper also in that future world demand, although growing at less than 6 per cent per annum, promises to continue strong. The problem here is not one of demand, but rather one of having sufficient reserves to continue to expand production at present rates. Science Council Special Study No. 13[7] states that, "while mineral reserves in the measured and indicated categories have noticeably increased in recent years as a result of accelerated exploration activities, the growth in reserves has not been proportionate to increases in production. Indeed, the relationship of reserves to annual production in 1967 was less for several minerals than it was in the mid-1950s". The report further estimates that exploration expenditures of up to $1 billion a year by 1985 (in terms of 1968 dollars) will be necessary to sustain a 4.5 per cent growth in this industry.

Nickel and nickel ores are our largest dollar earners in this category. Estimated cumulative production to 1985 is 6.0 million tons, while "measured" and "indicated" reserves in 1967 stood at 7.1 million tons.[8] Indications are that major producers do not expect to expand production facilities in Canada beyond 1975, unless there is a major new find similar to that of Thompson Manitoba. The most probable sites for major new developments in nickel are likely to be in New Caledonia and Australia.

The situation regarding copper is somewhat less clear, as there have been recent discoveries which have altered known reserves. In 1967, the "measured and indicated reserves" stood at 19.5 million tons, and the cumulative production to 1985, projecting past growth rates, was 13.9 million tons. The "estimated cumulative production" to 1985 and the "measured indicated reserves" for some other metals were: zinc production 30 million tons, reserves 31.1; platinum production 9.3 million ounces, reserves 13.3; iron production 1.2 billion tons, reserves 33; molybdenum production .425 million tons, reserves .614.

In the case of natural gas, we have already reached a situation where our exports are limited by considerations of supply, rather than of demand. Our established reserves stand at just over 50 trillion cubic feet; our production in 1970 was 2.3 trillion cubic feet[9], an increase of more than 15 per cent over 1969. Clearly, the spectacular growth that this product has had in recent years could be resumed only if there were equally spectacular new finds.

The situation with regard to crude oil is better only if we include the reserves of the Canadian Tar Sands. These, however, are very extensive, and it appears that most of the technical problems that have prevented large-scale exploitation before have now been solved.

The foregoing is not meant to imply that Canada is nearly depleted of all its resources, for such is not the case. New exploration will turn up new finds – but as time goes on, the finds will become increasingly expensive. Costs of exploitation will rise as we are forced to move further afield and as we turn to lower grades of ore. In the short-term perspective, we must ask ourselves if Canada can remain competitive with other countries, who are now at the beginning of their "mining boom".

Our resources are considerable, but we must also bear in mind that our

[7] Roger A. Blais, *et al.*, *Earth Sciences Serving the Nation*, Science Council of Canada, Special Study No. 13, Information Canada, Ottawa, 1971.

[8] *Ibid.*

[9] *The Mining Industry: Pillar of the Canadian Economy*, the Canadian Mining Association.

rate of exploitation is very high; we are among the world's leaders in the production of a number of key minerals. Thus, the life index for many of our minerals (i.e., the reserves, divided by the rate of production) is not as favourable as are those of certain other countries. Exploitation at a too rapid rate would move us up the cost curve ahead of other countries, and would make Canada a high-material-cost country.

In longer-term perspective, we must bear in mind that these resources are *non-renewable*, and that they are *finite*. Projecting past growth rates into the future would exhaust presently known reserves of several of our major minerals by 1990. With a vigorous exploration program, we could probably find most of the exploitable deposits and thus sustain the exponential rate of growth for a few more decades. But is this wise? Do we wish to be remembered as the generation that launched Canada on a program of rapid exploitation for the export, in raw or semi-processed form, of the resources which will be in such short supply for our children or grandchildren? Anything beyond the year 2000 looks very far away; but from 1972, the year 2000 is only as far in the future as 1944 is in the past.

Aluminum metal, which does not depend upon Canadian ore supplies, has been another of our strong performers. Here again, however, it would be unwise to project past performance into the future. The development of aluminum smelting in Canada has depended upon the availability of low-cost electricity. In future, this will no longer be sufficient reason to expand production here. The economics of this industry have shifted, with transportation costs becoming relatively more important and power costs relatively less important.

We will almost certainly wish to continue to buy products manufactured abroad in increasing quantity. It is hard to avoid the conclusion that we will increasingly have to balance these with manufactured products that we can sell abroad. In order to do this, it will be necessary to develop an internationally competitive manufacturing industry.

III. Science-Based Industry and Innovation in Canada

Two Views of Canadian Secondary Industry

As Canadians, we see ourselves as an industrially advanced nation. While we are prepared to admit that because of the youth of our country we may be culturally less evolved than certain countries of Europe, we do not show the same modesty in regard to our technological capabilities. In this respect, we tend to identify as North Americans, and compare ourselves with the United States. We see ourselves as very much smaller of course, somewhat poorer than they, and for these reasons unable to match the American pace in big science. In other respects, however, we see little difference between ourselves and our neighbours to the South. We have the same efficient telephone system, drive the same automobiles, fly the same aircraft, lighten our household chores with nearly identical appliances, and generally have the same mechanical and electronic gadgets as they. Moreover, we know that most of these things are coming out of production lines in "Canadian" plants. The plants themselves, apart from being very much smaller, resemble greatly their counterparts in the United States. There is little doubt in our minds: Canada is industrially and technologically well-developed; our secondary manufacturing industry, though young, is strong and growing. And is this not to be expected? The educational level of Canadians is among the highest in the world, scientific and technological activities are at quite a high level in absolute terms, and in addition we have direct access to much of the most advanced technological know-how of other nations, through multinational corporations.

This is the concept of Canada that appears to be the basis for many of the government-formulated policies that affect industry and the climate in which it must operate. It is the image held by consumers and by labour, and it determines the attitudes which these groups have toward industry. It is also the image that industry itself likes to project because it is quite flattering. Indeed, it is an image which we are all inclined to accept, because it is comfortable and pleasant. But is the image accurate? There are many, in Canada and abroad, who think not. Were these differing views on the state of development of Canadian secondary industry held by persons not knowledgeable about the Canadian scene, they might be easily dismissed. However, this is often not the case. Expressions of the view that the resemblance between Canadian and U.S. manufacturing industries is very superficial have come from many Canadian executives intimately involved in industry. Even more frequently this idea has been voiced by executives of parent companies in the U.S., U.K., and Europe. Similar views have been expressed by observers of international science and industrial policies in OECD, EEC, and universities in Europe.

A senior executive of a large U.S. science-based company, who is also on the board of directors of the Canadian subsidiary (whose sales are in the one hundred million dollars plus per annum range), told us flatly that his view of Canada was that we were a developing nation, and that it was foolish of us to try to act like an industrially developed nation in competition in world markets. Another executive, a director of the U.K. firm as well as a director of its Canadian subsidiary (a science-based secondary manufacturing company), stated: "Yours is a resource based economy....

why not do the things you are good at? You can grow wheat more efficiently than most, you have unexploited minerals and oil fields. Why do you want to get into the rat race of high-technology industry?... other countries are so far ahead of you now, it would be almost impossible to catch up." Needless to say, neither of these executives was very optimistic about the future of his Canadian "high-technology" operation. Yet another U.S. company executive, who is responsible for operations in Canada, told us that his company does not carry developments through to the production stage in Canada because the necessary services (e.g., tool design) are simply not available here. In the courses of our discussions with persons in the British, French and Belgian governments, and in OECD, it was often conveyed to us that, in terms of technological capability, Canada is not considered to be on a par with the larger countries in Europe (Germany France, U.K., etc.), nor even on a par with some of the smaller industrialized countries (such as Sweden, The Netherlands and Switzerland). While we cannot be sure that these rather pessimistic views are any more accurate than the more optimistic views that many of us hold, they do give us some reason for reflection, and some reason to seek more objective criteria for judging our position.

General Innovative Performance of Canada

In the OECD analytical report on Technological Gaps published in 1969[1], an analysis was given of ten member countries' performance in technological innovation. The assessment, based on 1963-1965 data, took into account the following five parameters:

1. The location of 110 significant innovations since World War II;
2. Monetary receipts from patents, licences and know-how;
3. Number of patents taken out in foreign countries;
4. Export performance in research-intensive countries;
5. Export performance in research-intensive product groups.

Of the 110 "significant innovations", which covered a wide range of science-intensive industries (electronic components, pharmaceuticals, scientific instruments, plastics, non-ferrous metals and computers), none was first reduced to practice in Canada. This earned Canada tenth place among the ten countries on this first point (Table III.1). However, as two other countries had only one innovation, and one other country had only two, the significance of the rank is not high; it does, however, clearly place Canada among the poorer innovators.

On the second criterion (monetary receipts for royalties), we come out just ahead of Japan, with receipts of $6.2 million against $5.9 million for last-place Japan. In this area one would intuitively expect that our proximity to the United States and the similarity of our markets, and the common languages with the U.S., the U.K. and, to a lesser extent, with France, Belgium and Switzerland, would give us very significant advantages over most other countries in selling our patents and know-how abroad. The very heavy involvement of multinational corporations in Canadian science-based

[1]OECD, *Gaps in Technology Between Member Countries: Analytical Report*, OECD, Paris, 1969.

Table III.1–Five Indicators of Ten Industrially Advanced Countries' Performance in Technological Innovation

Indicators		I. Location of 110 Significant Innovations Since World War II			II. Monetary Receipts for Patents, Licences and Know-How (1963-64)				III. Number of Patents Taken Out in Foreign Countries (1963)			IV. Export Performance in Research-Intensive Industries (1963-65)			V. Export Performance in Research-Intensive Product Groups (1963-65)		
Country	No. Emp. in Manuf. Ind. ('000)	Absolute No.	With U.S.A. Base Index 100	Index Ranked	Absolute No. in $m	With U.S.A. Base Index 100	Index Ranked	% Share of 10 Countries' Manuf. Exports	Absolute No. in '000	With U.S.A. Base Index 100	Index Ranked	% Share of 10 Countries' Exports in R.I. Ind.	With U.S.A. Base Index 100	Index Ranked	% Share of 10 Countries' Exports in R.I. Ind.	With U.S.A. Base Index 100	Index Ranked
	X	A	A/X	B	A	A/X	B	Y	A	A/Y	B	A	A/Y	B	A	A/Y	B
Belgium	1 645	1	20.6	5	7.9	34.2	5	5.8	1.8	12.4	10	3.5	45.4	10	3.0	37.6	10
Canada	2 428	0	0.0	10	6.2	18.3	8	5.5	1.9	13.9	9	3.4	46.3	9	2.9	38.3	9
France	7 940	2	8.5	8	46.3	41.9	4	9.8	9.3	38.1	6	7.7	59.0	7	6.5	48.2	8
Germany	12 385	14	38.3	4	49.4	28.7	7	18.1	29.9	64.7	2	22.1	92.0	2	21.1	84.7	2
Italy	7 776	3	13.2	7	9.9	9.1	9	7.5	4.6	24.6	7	5.9	59.1	6	5.7	55.2	6
Japan	17 129	4	7.9	9	5.9	2.4	10	8.1	3.5	17.4	8	5.3	19.3	4	5.9	52.9	7
Netherlands	1 847	1	18.3	6	26.0	101.2	1	5.9	6.4	43.6	5	5.3	67.3	4	5.9	72.7	5
Sweden	1 535	4	88.4	2	7.1	33.3	6	3.5	3.8	43.7	4	2.8	60.0	5	4.0	83.2	3
U.K.	11 798	18	51.8	3	76.1	46.4	3	13.2	15.2	45.2	3	14.2	80.7	3	13.9	76.5	4
U.S.A.	25 063	74	100.0	1	386.7	100.0	2	22.6	56.3	100.0	1	30.1	100.0	1	31.1	100.0	1

Notes: For indicators I, II and III, Column B was derived after dividing Column A by working population in manufacturing, (Column X) to correct for country size. The figures were then transformed into an index, with U.S.A. as the base 100 in each case, and ranked (Columns B).

For indicators IV and V, Columns B were derived after dividing Column A by percentage share of the countries' manufacturing exports (Column Y). The figures were again put in the form of an index with U.S.A. = 100, and ranked (Column B).

Sources:

Column A from Vol. III of OECD *Gaps in Technology Between Member Countries: Analytical Report*, Paris.

Column X from OECD *Observer Supplement* for 1967 Statistics.

Column Y from Vol. II of OECD *Gaps in Technology Between Member Countries: Analytical Report*, Paris.

Reproduced from OECD *The Conditions for Success in Technological Innovation*, Paris, 1971.

industry, with their many connections around the world, should also be an asset in this respect. Apparently, these have been insufficient to compensate for the negative factors involved. Moreover, Japan's receipts for technology have increased very sharply in recent years – from 2.5 billion Yen in 1963 to 16.6 billion in 1969[2]; a comparison based on more up-to-date information would be far less favourable to Canada. In addition, the basis of comparison used to calculate the ratings for these first two indicators was to divide the absolute values by the number of persons *employed in manufacturing*. Since Canada is the country with the smallest proportion of its total work force employed in the manufacturing industries, this gives Canada a much better rating than it would have if the basis of comparison had been total population, total number of qualified engineers and scientists, gross national product, gross expenditures in research and development, or almost any other criterion.

According to the third indicator (the number of patents taken out in foreign countries) Canada, with 1 900, comes out just ahead of Belgium, which has 1 800. On a per capita basis, however, this puts us well behind Belgium. On the other hand, on a per capita basis we rank substantially ahead of Japan, who had 3 500 in absolute terms. However, this is an area in which Japan has progressed very rapidly in recent years, and a comparison based on 1972 data would certainly be less favourable to Canada.

Indicators four and five give a measure of the relative export performance of each country's science-based industries. Again, Canada ranks near the bottom (ninth place out of ten countries), despite the similarity of our products to those in the U.S., and despite the advantages that the international links of multinational corporations might be expected to bring us.

If Canada's performance in the early 1960s was not good, there is no reason to believe that it had improved by late 1960s. For example, if one considers the number of patents granted in Germany in 1969, one finds that Canada was greatly out-performed by smaller countries like Holland, Sweden and Switzerland. This can be seen from Table III.2, which gives the number of patents issued by Germany to residents of a selected list of foreign countries. However, the natural trade links of the European countries with Germany might be expected to give a bias unfavourable to Canada. A comparison of patents granted in the U.S., on the other hand, could be expected to bias the figures in favour of Canada. Such a comparison is given in Table III.3. Here we see that Canada did indeed obtain more patents than Switzerland, Sweden, Italy or Holland; however, on a per capita basis the Swiss and the Swedes still out-perform us, while the Dutch do approximately as well as we. Considering the high degree of integration of the U.S. and Canadian economies, and considering that our trade with the U.S. greatly exceeds that of any other country (including Germany, the U.K. and Japan, who all obtained twice as many patents as Canada), this result is indeed disheartening.

[2]Hiromu Susuki, "Industrial Technology of Japan", *Industria*, October 1971.

Table III.2–Number of Patents Granted in Germany, 1969

Resident Country	Number
United States	4 483
United Kingdom	1 140
France	1 114
Netherlands	606
Switzerland	832
Japan	476
Sweden	353
Italy	228
Canada	97

Source: Blatt Fuer Patent-Munster-Und Zeichenwesen, Seiten 69-108, Marz 1970. page 78.

Table III.3–Number of Patents Granted in U.S.A., 1969

Resident Country	Number
United States	50 395
France	1 808
Germany	4 523
Italy	556
Japan	2 152
Sweden	673
Switzerland	1 058
United Kingdom	3 175
Netherlands	558
Canada	994

Source: U.S. Commissioner of Patents, *Annual Report Fiscal Year 1970*, Washington, 1970.

General Performance of Canadian Manufacturing Industry

Canada's poor performance in innovation is paralleled by the poor performance of her manufacturing industries. Industrially advanced countries generally have positive trade balances in manufacturing industries, particularly in those industries that are highly knowledge-dependent.

A starting point for comparing the overall performance of Canadian manufacturing industry with that of other countries is a comparison of exports in broad categories of products, such as is available from United Nations statistics. This information (Table III.4) shows Canada as a country that has a relatively higher portion of its exports in raw materials, and a relatively lower portion in chemicals and manufactured products, than most industrial nations. Moreover, there are factors not apparent in these statistics that make our performance less favourable than the raw data would indicate. One such factor is the large two-way flow in automobiles and parts between Canada and the U.S. as a result of the Auto Pact, which accounts for the bulk of our exports in the "machinery" category, and which makes them appear more significant than they are in reality. (Our imports in this category are similarly inflated due to the Auto Pact, but again this has little real significance.) A second point is that by far the largest item in the category of "other manufactured products" is newsprint (more than one-third of the total), which is quite unsophisticated as manufactured products go. There are several other items with rather rudimentary manufacturing contents in this latter category, which contribute significantly to Canada's exports.

Table III.4–World Trade by Commodity Classes and Regions, 1969 (All Numbers are Percentages)

Exports from	Food, etc.	Raw Materials Fuels, etc.	Chemicals	Machinery	Other Manufactures
World	13.5	20.1	7.1	28.3	29.1
United States	11.9	13.4	9.0	43.8	18.7
Latin America	41.3	41.7	2.0	1.7	13.2
EEC	9.9	8.3	10.7	35.2	35.6
EFTA	8.5	9.2	9.7	35.2	36.1
United Kingdom	5.9	5.2	9.7	42.0	34.8
Centrally planned economies, Europe and U.S.S.R.	11.5	20.4	4.8	31.6	24.7
South Africa	22.4	29.8	3.4	6.8	35.0
Developing Africa	24.3	52.7	1.2	.1	21.2
Japan	3.6	1.8	6.4	38.6	48.7
Asian Middle East	5.2	86.0	.1	.1	7.0
Other Asia	19.2	36.6	1.9	5.1	36.2
Centrally planned economies, Asia	30.2	20.8	4.4	2.8	40.4
Australia, New Zealand	38.0	41.1	3.8	4.2	11.7
Rest of World	19.1	60.3	3.7	2.0	13.9
Canada	9.9	27.6	3.3	35.1	23.4

Source: The Monthly Bulletin of Statistics, Vol. XXV, No. 3, United Nations, New York, March 1971.

What is perhaps of more concern is that there has been no apparent trend toward improvement. Indeed, Canada appears to be shifting slightly toward a greater reliance on primary materials. Table III.5 shows the

Table III.5–Rate of Increase of Exports for Selected Categories, 1965-1969 (All numbers are Percentages)

Exports from	Raw Materials, Fuels, etc.	Chemicals	Machinery	Other Manufactures
World	28.5	57.5	69.1	53.4
United States	17.1	40.8	63.7	42.7
Latin America	15.6	65.6	251.6	67.9
EEC	31.8	71.1	69.2	56.6
EFTA	18.0	49.3	40.4	31.2
United Kingdom	11.3	33.3	27.5	33.9
Centrally planned economies, Europe and U.S.S.R.	21.7	29.4	44.8	25.7
South Africa	11.3	43.1	119.7	80.7
Developing Africa	51.8	35.0	38.3	85.5
Japan	23.2	85.4	133.7	69.7
Asian Middle East	39.7	126.3	239.1	94.1
Other Asia	32.5	51.5	158.8	75.3
Centrally planned economies, Asia	.88	61.3	125.0	21.3
Australia, New Zealand	30.6	129.4	53.6	69.0
Rest of World	15.4	121.4	512.5	228.6
Canada	40.6	56.9	305.0	38.8

Source: The Monthly Bulletin of Statistics, Vol. XXV, No. 3, United Nations, New York March 1971.

percentage increase for various export commodities for the same countries and trade areas.

It emerges from these comparisons that, on the whole, developing areas have experienced more rapid increases in their exports of chemicals, machinery and other manufactured products than the world increase in trade in these commodities. They have, in other words, begun to catch up. Canada, while having a trade pattern that is intermediate between an industrialized and a developing country, has not increased its exports of chemicals and other manufactured products as rapidly as world trade has increased in these two commodities. In the other commodity, machinery, the statistics indicate that we have done very well indeed. However, as was pointed out earlier, the largest portion of this is artificial, being simply the result of increased *two-way* flow in automobiles and automobiles parts. Only about one-third of it is real, reflecting the net improvement in our trade balance in motor vehicles and parts. While this improvement in our auto trade has been a favourable feature of our economy during the past decade, it was not achieved without costs – costs which are not apparent from the macro-statistics but which are nevertheless very real, and which in the long term may well lead us to question whether the benefits of the Auto Pact, which today seem so obvious, were worth the price. This subject will be touched on again in a later section.

It can also be seen from Table III.5 that our rate of increase of exports in raw materials has been well above the world average in these materials. It seems clear, therefore, that on a relative basis Canadians are increasingly becoming "hewers of wood and drawers of water". This becomes even clearer if one looks in more detail at which products make the largest positive contribution to Canada's balance of trade, along with some of the products that make the largest negative contribution (Table III.6). Our principal net exports are wood and wood products, metals and their ores, wheat and fuels. Our principal net imports, on the other hand, are manufactured goods.

While comparative data on our performance since 1969 are difficult to obtain, we have every reason to believe that our manufacturing industry has not done any better since that time. As was pointed out in Science Council Report No. 15, employment in the manufacturing industries appeared to have levelled off, and may in fact have been dropping, at the end of 1971. Likewise, the profitability of our manufacturing industries has been falling in recent years. The data presented in Report No. 15 are reproduced in Figures III.1 and III.2 here.[3]

Performance in High-Technology Sectors

Even more significant than the performance in overall manufacturing is the performance in certain key high-technology sectors. OECD, in its study of *Gaps in Technology*, identified a number of sectors which it considered to be of particular importance to the industrial development of a nation. They were: electronic components, plastics, computers, pharmaceuticals, non-

[3]Science Council of Canada Report No. 15, *Innovation in a Cold Climate: The Dilemma of Canadian Manufacturing*, Information Canada, Ottawa, 1971. (Figure 2, page 16; Figure 3, page 17).

Table III.6–Selected Products in which Canada has a Large Positive or Negative Trade Balance, 1969 (In Thousands of Dollars Canadian)

Positive Balance, 1969	
Pulp and Paper Products	1 872 379
Lumber	649 564
Copper Ores, Concentrates and Alloys	487 880
Wheat	472 703
Nickel Ores, Concentrates and Alloys	404 835
Aluminum Ores, Concentrates and Alloys	306 475
Iron Ores and Concentrates	303 681
Asbestos, Unmanufactured	214 850
Fertilizers and Fertilizer Materials	160 788
Distilled Alcoholic Beverages	157 133
Natural Gas, Crude Petroleum, Petroleum and Coal Products	127 822
Negative Balance, 1969	
Machinery	1 244 079
Chemical Products	368 078
Electrical Products	345 561
Transportation	311 571
Scientific Instruments	224 038
Communications	193 256
Electronic Computers and Parts	160 527
Photographic Goods and Film	138 333
Books and Pamphlets	116 718

Note: Due to a lack of complete correspondence between export and import categories, the classifications are somewhat arbitrary.
Sources:
–Canada, Statistics Canada, *Canada Yearbook 1970-71*, Information Canada, Ottawa, 1971.
–Canadian Electrical Manufacturers Association (CEMA), *Goals to 1975*, Toronto, 1970.
–Canada, DBS, "Imports by Commodities". Catalogue No. 65-007.
–Canada, DBS, "Imports by Commodities". Catalogue No. 65-004.

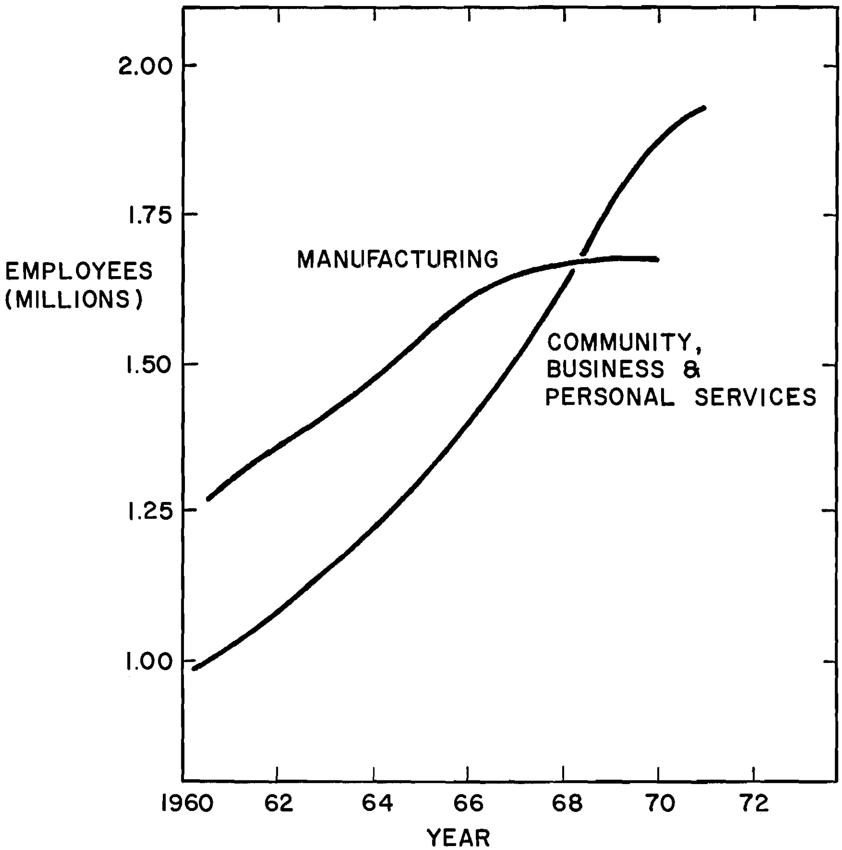
ferrous metals, scientific instruments, man-made fibres and steel. An examination of the available data on Canadian production and exports in these products revealed that, on balance, our performance is even less favourable here than it is in general manufacturing. Our trade balance in most of these products is negative, and this to a very substantial degree.

The fastest-growing major component of the chemical industry has been plastics (Figure III.3). In Western Europe during the period 1958 to 1966, the output of this sector increased by 380 per cent, in comparison to an average of 220 per cent for the chemical industry as a whole. Progress in Japan during this period was even greater, while in the United States it was marginally lower.

Comparison of Canada's performance in plastic material with that of the countries of Western Europe, Japan and the United States (Table III.7) shows Canada to have the most unfavourable balance of all countries. Even countries with much smaller domestic markets than Canada (such as Belgium, the Netherlands and Sweden) managed to export more plastic materials than Canada. This may be due in part to their participation in trading blocks (EEC or EFTA), as the data in Table III.7 tend to indicate that the existence of these trade areas has an effect on their level of foreign trade. Other data, for the chemical industry in general[4], show that the

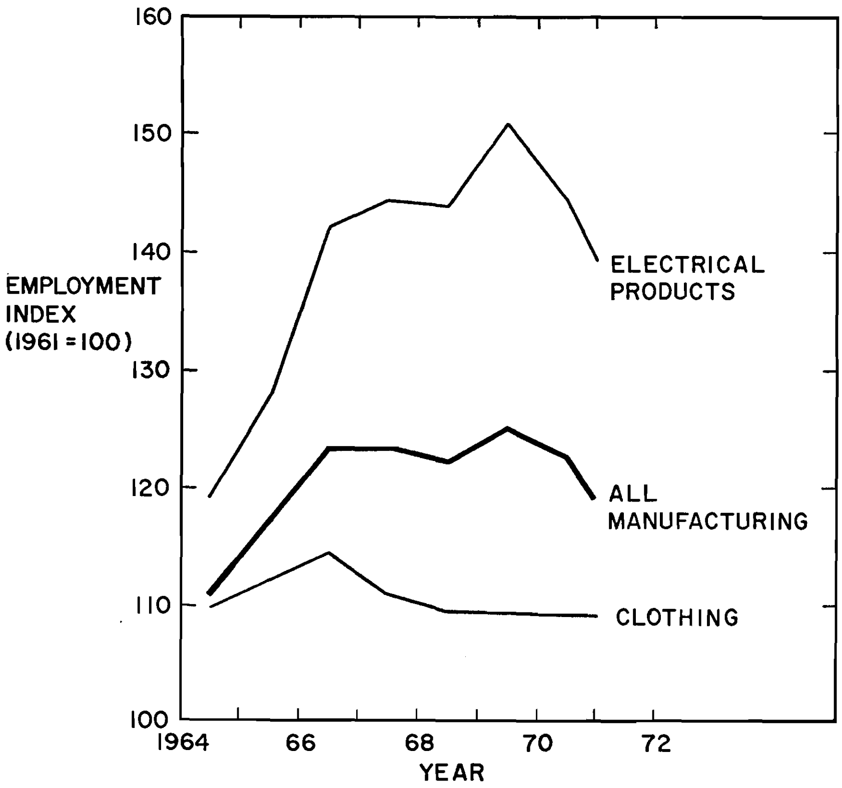
[4]OECD, *The Chemical Industry, 1966-67*, Paris, 1968.

Figure III.1–Employment in the Manufacturing and Service Industries in Canada



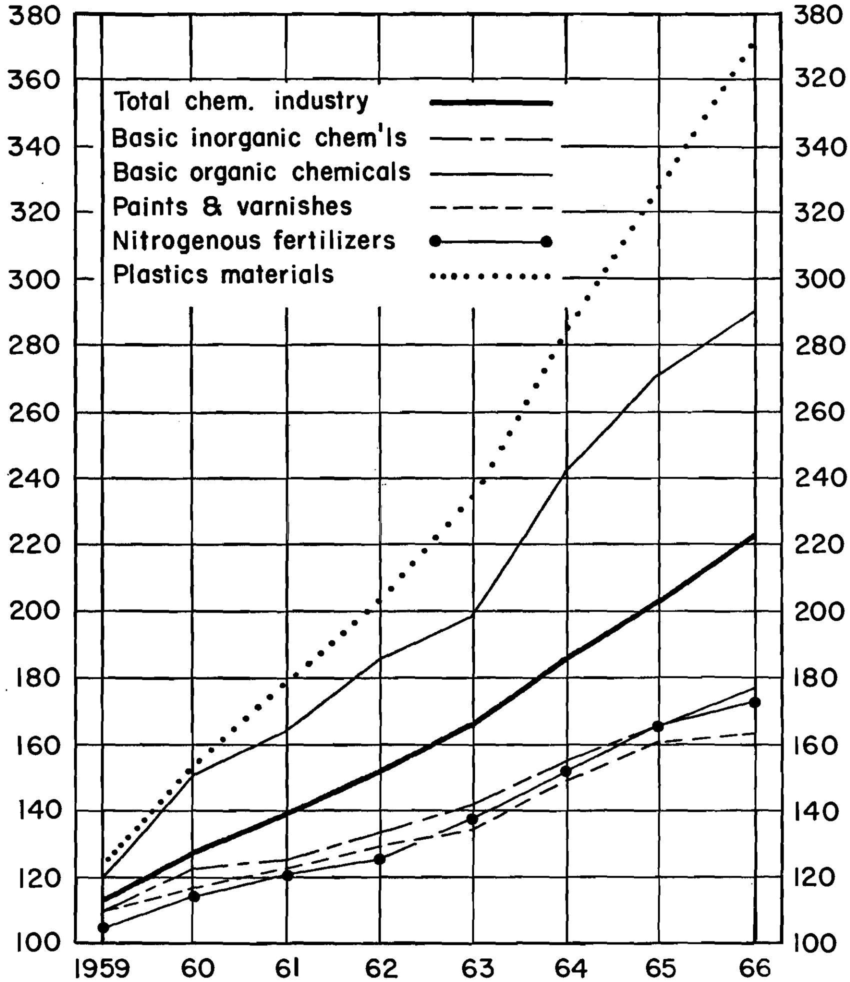
Source: DBS 72-008; Vol. 6, No. 1 and Vol. 7, No. 2.

Figure III.2–Employment Indices for Some Sectors of Manufacturing in Canada



Source: Canadian Statistical Review, DBS 11-003.

Figure III.3–Development of the Chemical Industry and of Certain Branches in Western Europe (1958 = 100)



Source: OECD, *The Chemical Industry, 1966-67*, Paris, 1968.

trade between member countries of the European Economic Community (EEC) accounts for about 75 per cent of their European trade and about 50 per cent of their world trade. For the countries of the European Free Trade Association (EFTA), member-country trade accounts for about 50 per cent of European trade and for about 35 per cent of world trade. This would indicate that belonging to a trade group increases the level of a country's international trade to a significant extent, but it in no way makes the markets of the other member countries as accessible as its own.

Table III.7–Plastics Trade, 1969 (Millions of Dollars)

Country	Exports	Imports	Trade Balance
United States	589.7	99.0	490.7
Germany	820.2	373.6	446.6
Japan	328.3	58.0	270.3
Netherlands	349.1	192.7	156.4
United Kingdom	308.1	222.6	85.5
Belgium/Luxembourg	183.6	148.0	35.6
Italy	212.5	185.6	26.9
Norway	30.1	51.9	− 21.8
France	241.4	281.3	− 39.9
Sweden	68.9	127.8	− 58.9
Spain	6.7	74.8	− 68.1
Canada (1965)	27.8	173.7	−145.9
Canada (1970)	33.7	221.2	−187.5
Plastic Fabricated Materials	25.3	108.8	− 82.7
Plastics and Synthetic Resins*	8.4	113.2	−104.8

*Does not include synthetic rubber, for which exports were $57.8 million and imports $42.2 million.

Sources:

–OECD, *The Chemical Industry 1969-70*, Paris, 1971.

–Canada, Department of Industry, Trade and Commerce, *Chemical and Chemical Product Statistical Review*, prepared by the Programmes Division, Chemicals Branch, March 1971.

Electronic computers are perhaps the fastest-growing of major high-technology products. In the United States in the period from 1958 to 1969, this product had a twelve-fold increase in value of goods produced (Table II.6, Chapter II). We were unfortunately unable to make a comparison of the performances of different countries on this item; instead, we have had to content ourselves with data on Canadian performance and some 1966 data for Japan and the United States. These are shown in Table III.8.

Pharmaceutical products is another sector of the chemical industry which has been growing very rapidly. It is also the most science-intensive, in that R & D accounts for a greater proportion of the costs of production in pharmaceuticals than in any other category of chemicals. Again, we find Canada at or near the bottom of the list in a comparison of trade performances among Western industrialized countries. (Table III.9.)

The scientific instruments sector is important to industrial countries, not only because it is a sector that is developing very rapidly, but also because it has an incidence upon the development of sophisticated components and materials and its products are vital to research, development and the functioning of high-technology industry. As may be seen from

Table III.8–Electronic Computers Trade (Millions of Dollars)

Country	Year	Exports	Imports	Trade Balance
Canada	1965	27.1	56.6	– 29.5
	1966	32.9	105.1	– 72.2
	1967	44.9	126.5	– 81.6
	1968	41.4	121.0	– 79.6
	1969	58.7	177.9	–119.2
	1970	88.0	217.8	–129.8
Japan	1966	7.3	46.7	– 39.4
U.S.	1966	295.2	43.3	241.9

Sources:
–Canada, Department of Communications, *Telecommission Study 2(g); Description of the Canadian Telecommunications Manufacturing Industry*, Information Canada, Ottawa, 1971.
–*Electronics Industry: Facts and Information 1966-1970*, Electronics Industries Association of Canada, Ottawa, 1971.
–OECD, *Gaps in Technology: Electronic Computors*, Paris, 1969.

Table III.9–Pharmaceutical Trade, 1966 (Millions of U.S. Dollars)

Country	Exports	Imports	Trade Balance
United States	269.0	73.0	196.0
Germany	258.9	74.9	184.0
United Kingdom (1965)	189.8	31.8	158.0
France	122.8	12.8	110.0
Netherlands	78.9	45.8	33.1
Italy	81.4	81.9	– .5
Spain (1965)	2.5	22.1	– 19.6
Japan (1964)	30.9	57.3	– 26.4
Belgium	32.7	66.2	– 33.5
Canada (1965)[a]	11.6	36.2	– 24.6
Canada (1969)[b]	20.9	62.1	– 41.2
Canada (1970)[b]	24.6	76.4	– 51.8

Notes:
[a]Canadian figures were not submitted to OECD. 1965 figures are from DBS Catalogue No. 65-004, "Exports by Commodities", and are converted to U.S. dollars using the 1966 exchange rate.
[b]1969 and 1970 figures for Canada are from Canada Department of Industry, Trade and Commerce, *Chemical and Chemical Product Statistical Review*, prepared by the Programmes Division, Chemicals Branch, March 1971.
Source: OECD, *Gaps in Technology: Pharmaceuticals*, Paris, 1969.

Table III.10, Canada's performance is by far the worst of the OECD countries for which we could obtain data.

We find much the same pattern in electronic components as was found in the other high-technology products – a very strong negative balance of trade. Electronic components is another class of products that has shown very rapid growth during the past decade (cf. Table II.6). These are products which are also highly science-intensive. In the United States the work force in this group includes 10.2 per cent engineers and scientists. This compares with 21.4 per cent in military and space electronics, 7.4 per cent in consumer electronics and 5.9 per cent in industrial-commercial electronic products. This industry is also quite labour-intensive, employing particularly large numbers of skilled and semiskilled factory workers. The negative balances of $105.1 million in 1965 and $121.6 million in 1970, while already greater than those of any other country, are probably understated, as many components come in under tariff items that do not identify them as such. The two most important categories of electronic components coming in under other tariff items are the many thousands of components that enter on circuit boards as computer parts, and the components for automobile radios that are admitted as auto parts. (See Table III.11)

Table III.10–Scientific Instruments Trade, 1966 (Millions of Dollars)

Country	Exports	Imports	Balance
United States	196.00	31.5	164.5
United Kingdom	55.54	26.48	29.06
Japan	42.10	31.47	10.63
Sweden	22.99	41.37	− 18.38
France	25.53	48.51	− 22.98
Italy	11.52	38.24	− 26.72
Canada	23.9	149.3	−125.4
Canada (1971)	67.8	228.2	−160.4

Sources:
–OECD, *Gaps in Technology: Scientific Instruments*, Paris, 1968.
–DBS, "Exports by Commodities", and DBS "Imports by Commodities".

Table III.11–Electronic Components Trade, 1965-1966 (Millions of Dollars)

Country	Exports	Imports	Balance
United States	238.1	151.2	86.9
Japan	176.7	22.6	154.1
United Kingdom	128.2	103.8	24.4
Germany	165.2	108.5	56.7
France	86.7	107.1	− 20.4
Italy	72.3	101.4	− 29.1
Canada (1965)	25.3	130.4	−105.1
Canada (1970)	60.2	181.8	−121.6

Sources:
–OECD, *Gaps in Technology: Electronic Components*, Paris, 1968.
–EIA of Canada, *Facts and Information 1966-70*, Ottawa, 1971.

The machine tools industry is important because it provides a part of the means whereby "inventions" may be translated into "innovations". This link in the innovative chain is especially weak in Canada, and this is reflected by our weak position in machine tools trade (Table III.12).

Man-made fibres experienced a growth of about 400 in the United States during the period 1958 to 1969. They were thus one of the fastest-growing high-technology products of the decade. Prospects for the future are for continued gains in non-cellulosic fibres and for possible declines in the traditional cellulosic fibres. Overall, it appears that past rates of development will not be sustained.[5] Western Europe and Japan have shown the most strength in these products, with the U.S. and Canada net importers. Although in absolute numbers the U.S. has a larger negative balance than Canada, on a proportional basis it is not nearly as significant. (See Table III.13.)

[5]OECD, *Man-made Fibres, Production, Consumption and Capacity*, Paris, 1969.

Table III.12–Machine Tools Trade Balance, 1966 (Millions of U.S. Dollars)

Country	Exports	Imports	Balance
United Kingdom	119	105	14
France	66	99	– 33
United States	222	135	87
Japan	52	27	25
Italy	87	61	26
Spain	11	64	– 53
Canada	13	88	– 75
Canada (1971)	25	138	–113

Sources:
–OECD, Working Journal, Sector Report, *Machine Tools*, Paris, 1968.
–DBS, "Exports by Commodities" and "Imports by Commodities".

Table III.13–Man-made Fibres Trade, 1968 (1 000 Metric Tons)

Country	Exports	Imports	Balance
OECD Europe	1 112.1	659.9	452.2
United States	89.6	124.1	– 34.5
Japan	225.8	.9	224.9
Canada	10.2	32.7	– 22.5
Canada (1971)	10.6	29.8	– 19.2

Sources:
–OECD, *Man-Made Fibres, Production, Consumption and Capacity*, Paris, 1969.
–DBS, "Exports by Commodities", and "Imports by Commodities".

Although iron and steel are not normally thought of as high-technology products, and although in recent years they have not experienced the same rapid development – both qualitative and quantitative – as have most of the other products in this series, this industry is fundamental to any industrial country. For that reason it was selected by OECD for special consideration. Here Canada does well on its trade balance (Table III.14). The industry appears quite healthy, with good productivity and up-to-date technology.

Table III.14–Iron and Steel Products Trade, 1968 (1 000 U.S. Dollars)

Country	Exports	Imports	Balance
United States	313 185	1 604 733	–1 291 548
Japan	1 275 869	224 657	1 051 212
Canada	225 570	150 926	74 644
Canada (1971)	750 460	415 378	335 082

Sources:
–OECD, *The Iron and Steel Industry*, Paris, 1970.
–DBS, "Exports by Commodities" and "Imports by Commodities".

The final sector selected for special study by OECD in its *Gaps in Technology* series was that of non-ferrous metals. Like iron and steel, this group was selected not because it is itself a high-technology high-growth sector, but rather because of the strategic importance of these metals for industrial development. The growth in primary metals in the period 1958 to 1969 in the U.S. (Table II.6) was only 149 per cent, appreciably lower than the average for manufacturing, which was 174 per cent. In the production of these metals in primary forms Canada does very well indeed (Table

III.15). This is, however, much more an accident of nature than evidence of technological capability. Canada has substantial mineral resources and we have emphasized their development; it is for this reason that we lead in exports of copper and nickel. Our position in aluminum we owe, of course, to our low-cost hydro-electric power.

Table III.15–Selected Non-Ferrous Metals, Trade Balance*, 1965 (Thousand Metric Tons)

Country	Primary Aluminum	Semi-Fabric Aluminum	Refined Unwrought Copper	Semi-Fabric Copper	Refined Nickel
Norway	232.7	– 2.2	7.4	–16.9	31.2
Austria	30.6	14.6	– 17.5	– .2	– 2.2
France	111.0	19.0	–251.9	15.4	– 20.1
Japan	8.5	25.2	– 81.1	23.0	– 2.7
Italy	– 1.7	8.2	–172.2	17.9	– 7.9
Spain	– 10.7	– 9.0	.2	–16.2	– 1.1
Netherlands	– 11.3	–13.5	– 28.7	–32.1	– 0.7
Yugoslavia	– 19.8	21.6	– 6.2	10.4	– 0.7
United States	–293.8	4.9	172.1	–19.7	–148.0
Germany	–134.2	26.9	–196.3	1.1	– 21.8
Turkey	– 84.3	n.a.	n.a.	n.a.	n.a.
United Kingdom	–324.1	22.1	–465.7	46.4	1.5
Belgium/Luxembourg	–114.7	80.1	113.4	58.2	– 1.2
Canada	635.0	2.9	181.2	37.7	111.6
Canada (1971)	790.5	–68.3	263.5	29.1	101.0

*exports minus imports
Sources:
–OECD, *Gaps in Technology: Non-Ferrous Metals*, Paris, 1969.
–DBS, "Exports by Commodities", and "Imports by Commodities".

However, if we look in more depth at our performance in the more science-intensive forms of these minerals we find, unfortunately, that we do little better there than in plastics, pharmaceuticals, electronic components, etc. For example: we are the world's largest producer of nickel, but we are net importers of stainless steel and manufactured nickel products, including "cold climate" nickel-cadmium batteries; we are the world's second largest producer of aluminum, but we import it in its more sophisticated forms, such as etched and formed foil for use in capacitors and precision aluminum parts for use in aircraft; we are the world's largest exporter of pulp and paper, but we import much of our fine paper and virtually all of the highly sophisticated paper, such as backing for photographic film and dielectric papers for use in electronic components; we are one of the world's principal sources of platinum, but it is all exported for refining and processing and reimported in finished forms; we are large exporters of natural gas and petroleum, but we are net importers of petrochemicals; and, although we are the world's foremost exporter of raw asbestos fibres, we are net importers of manufactured asbestos products. The above is not a selected list of products in which our performance is particularly bad. With the exception of platinum, each of them can be found among the ten products in which our export performance, in net terms, is the best (cf. Table III.6). Further evidence of our failure to derive secondary manufacturing activity from those resources in which we would expect to have a comparative advantage is illustrated in Table III.16.

Table III.16–Canadian Performance in the Minerals Industry, 1969 (Trade Balance in Thousands of Dollars)

Metals	Canada's Position and Percentage of World Production		Ores, Concentrates and Scrap	Primary Refined Forms	Fabricated Forms
Nickel	1st	40%	154 670	241 160	− 5 825
Zinc	1st	22%	102 606	74 388	− 770
Asbestos	1st	47%	104	216 171	− 7 633
Silver	1st	15%	33 914	31 616	− 1 171
Potash	2nd	19%	88 384[a]	−1 849[b]	
Molybdenum	2nd	21%	49 292	−1 036[c]	
Titanium	3rd	21%	n.a.	−2 652[d]	
Cadmium	4th	13%	n.a.	n.a.	n.a.
Cobalt (1968)	2nd	9%	n.a.	n.a.	n.a.
Lead	4th	9%	26 179	26 946	100
Aluminum	3rd	11%	− 83 306	442 897	−55 103
Uranium	2nd	18%	24 507	n.a.	n.a.
Platinum	3rd	9%	36 288	− 1 079	− 4 087
Gold	3rd	6%	n.a.	n.a.	n.a.
Iron and Steel	5th	5%	303 680[e]	34 711[f]	− 1 511[g]
Magnesium	4th	5%	—	2 076[h]	—
Copper	5th	9%	223 981[i]	250 809[i]	32 228[i]

Notes:
[a]Fertilizer grade potash
[b]Potassium based chemicals
[c]Includes both primary and fabricated forms
[d]Includes pure oxides, extended oxides and metal
[e]Iron ore
[f]Balance of trade in pig iron
[g]Balance of trade in steel expressed in tons × 1 000
[h]Includes alloy imports
[i]Includes copper alloy
Source: Canadian Minerals Year Book 1970, Information Canada, Ottawa, 1969.

In virtually all of these minerals for which we are one of the world's principal sources of supply, we are net importers of the fabricated forms – even though the forms covered under these listings are mostly very elementary. More detailed breakdowns of our trade balance on some of these and on some categories from the paper industry are given in the appendix.

Clearly, our record at innovation is disappointing and *the performance of our industry, in key sectors of manufacturing, is a cause for national concern.* We seem to have been unable to harness science and technology in order to achieve our economic objectives.

Sectors of Performance

The scientific and technological strength of a nation is derived from combined strength in three sectors: higher education, government and industry. It is not the mere arithmetic sum of the sector capabilities that determines total capability, but rather some more complex function derived from the interdependence that exists between sectors. As the three sectors operate more nearly in series than in parallel, the strength of the system will depend upon the interface between the sectors; but under no circumstances can it be stronger than the final "output" link, which for industrial performance is of course industry.

The Higher Education Sector

Canada has long placed a high value on education, and the percentage of all resources devoted to this sector (9% of GNP in 1969) is more than is spent by most industrially advanced nations of Europe and Asia. On a per capita basis, only the United States spends more than we do on education. As is shown by Table III.17, Canada's public expenditures on education in 1968 were $253 per capita, almost exactly as much as in the U.S. and more than twice the amount spent in the U.K. or France. Moreover, a large portion of this was spent on higher education. Support for universities has grown very rapidly since 1964, reaching an estimated $2 billion for the fiscal year of 1970-71. Research and graduate education accounts for a substantial portion of the university expenditures in Canada. Macdonald[6] has estimated that 55 per cent of total university expenditures were for what he called "Research and Research Training". Allowing that this estimate may be high, as others in the field believe it to be, and that the research component has grown less rapidly in recent years than the education component, it still seems probable that the postgraduate education and research expenditures in all disciplines in Canadian universities are now in excess of $500 million. The disciplines most generously supported have been the natural sciences, the health sciences and engineering. Taken together, these disciplines have accounted for nearly two-thirds of the graduates at the Ph.D. level. By comparison, less than 50 per cent of Ph.D.s in the United States[7] are in these disciplines. On a per capita basis, our present output of Ph.D.s in science and engineering is second only to the United States in the western world. Likewise, Canada is second only to the United States in the average number of years' schooling of the labour force, in the average number of years' schooling of high-level manpower and in the average number of years' schooling of scientific and technical personnel.[8]

In summary, Canada has emphasized education and continues to do so; within the education system, science and technology have received their

Table III.17–Total Public Expenditures on Education, 1968

Country	Expenditure	Population	Dollar/Capita
France	5 629 535	49 920	113
Italy	3 574 948	52 750	68
Japan	5 748 656	101 080	57
New Zealand	211 185	2 751	77
U.S.S.R.	15 981 982	237 798	67
U.K.	5 332 098	55 283	96
U.S.	51 300 000	201 152	255
Canada	5 249 115	20 772	253

Sources:
–*U.N. Statistical Year Book, 1970*, United Nations, New York.
–*U.S. Statistical Abstract, 1970*, Washington, 1970.

[6]John B. Macdonald, *The Role of the Federal Government in Support of Research in Canadian Universities*, Science Council of Canada Special Study No. 7, Queen's Printer, Ottawa, 1969.

[7]U.S. National Science Board, "Graduate Education: Parameters for Public Policy", Washington, 1969.

[8]OECD, *The Conditions for Success in Technological Innovation*, Paris.

fair share of support. The level of our activity in this sector seems adequate, and there is little to make us believe that failings in the higher education sector are the cause of our overall poor performance in using science and technology.

Table III.18–Proportion of Public Education Expenditures Spent on Higher Education

Country	Year	%
Germany	1961	13
Belgium	1959	6
United States	1965	26
France	1964	15
Italy	1963	10
Japan	1963	13
Netherlands	1961	16
United Kingdom	1964	14
Sweden	1961	9
Canada	1964	25

Source: Review of National Science Policies: Canada, OECD, Paris, 1969.

The Federal Government in R & D Performance

Policies of the Federal Government have been held responsible for the relative failure of Canada's science policy.[9] While there is no doubt considerable truth in this, since governments must accept responsibility for the overall industrial climate, there is little evidence that the Federal Government has failed to appreciate the importance of research and development. That this has been recognized is demonstrated by the extensive development by the government of its own in-house research and development activities. It is also demonstrated by its willingness to spend substantial sums of money on R & D performed outside of its laboratories.

In a recent report on R & D in member countries, OECD classifies Canada as a "government funded country"[10] (i.e., a country where government funds account for more than 50% of total R & D expenditures). Comparisons between OECD member countries of government R & D expenditures as percentages of GNP place Canada higher than Norway, Germany, Sweden and Japan, on a par with The Netherlands, and lower than the U.K., France and the United States.[11] If one considers that the latter three have placed heavy emphasis on "National Security and Big Science", one must conclude that the level of support for research and development by the Federal Government is not out of line with that of other countries. Moreover, the OECD data show that, during the period 1963 to 1967, Canada had the highest annual growth rate of gross expenditures in research and development (GERD) of all "large" industrialized member countries. (The classification of Canada among the large industrialized countries is that of OECD, and not of the author.) The intramural R & D activities of the Canadian Federal Government amounted to about .47 per cent of GNP,

[9]Canada, Senate Special Committee on Science Policy (Chairman: Maurice Lamontagne), *A Science Policy for Canada*, report, Ottawa, 1970.

[10]OECD, *R & D in OECD Member Countries: Trends and Objectives*, Preliminary report SP(71) 10, Paris, 1971. (By permission.)

[11]*Ibid.*

which places us below France and the United Kingdom and about 25 per cent above the United States.

Table III.19–R & D as Percentage* of GNP, 1969

Country	Performed by Government	Paid by Government
United States	.38	1.55
United Kingdom	.55	1.15
France	.55	1.04
Germany	.08	.72
Norway	.21	.59
Japan	.20	.52
Ireland	.33	.36
Sweden	.18	.35
Finland	.18	.32
Canada	.47	.73

*All percentages are approximate
Source: Ministry of State for Science and Technology (MOSST), *Scientific Activities: Federal Government Costs 1958-59 to 1971-72*, Ottawa, November 1971.

Since 1967, the growth rate of federal expenditures has been reduced to approximately one-half of what it was during the previous period. However, the percentage distribution of these funds among the three sectors has remained essentially the same as it was in 1967; the in-house scientific activities of the Federal Government account for approximately two-thirds of federal expenditures. Despite much talk in Ottawa of contracting-out more of the government's research needs, there is little evidence that this is occurring.

Government Interest in Industrial R & D

Federal Interest

If the Federal Government has long recognized the importance of R & D to the achievement of its missions, it must also be said that it has long recognized the importance of R & D to industrial and economic development. As early as 1917, this interest was clearly demonstrated by the creation of the National Research Council (NRC). The Order in Council creating the Honorary Advisory Council (later to become a National Research Council) clearly shows that the motivation leading the government to the creation of this body was to assist industry to make better use of science and technology. However, one must agree with Lamontagne[12] that the National Research Council has in fact not been very effective in achieving this objective. The difficulty, it seems, has been not so much that the Council has deliberately deviated from its proposed objective, but rather that the means it has taken to achieve that objective have not proven effective. The underlying philosophy which appears to have guided the successive presidents of NRC has been that the most important thing to develop is "scientific excellence"; if this could be achieved, economic and other social benefits would follow.

But after the "scientific excellence", which in fact was achieved, very little followed – or, more correctly, very little followed in Canada in terms

[12]Canada. Senate Special Committee on Science Policy, *op. cit.*

of industrial benefits. A principal reason for this relative failure, it seems, was that the remainder of the process, from science and technology to products and processes, was left largely to take care of itself. There were too few people in Canada, whether in NRC or in industry, who were primarily concerned with translating *widely available* or *newly discovered* science and technology into products and processes that could benefit Canadian industry, relative to the number who were concerned with generating *new* science and *new* technology. Although there has been some improvement in recent years, the problem continues to exist today; the intellectual requirements and the overall difficulty of drawing social and economic benefits from technology once it exists continue to be underestimated. With regard to its application in industry, there are too few truly excellent people doing development, product engineering, production engineering and industrial design. Has NRC been "dropping the ball" too early, or has industry not been picking it up as it should have? Whichever it is – and there no doubt has been some of both – one thing appears clear: the "ball" does not get transferred very efficiently.

Provincial Interest

The existence of research councils in eight of the ten provinces is evidence that provincial governments also recognize the importance of technology and innovation in industrial development. That this interest on the part of the provinces is not just recent is attested to by the fact that two of these councils (or foundations) were formed before 1930, and five were in existence before 1950. While their roles and objectives vary somewhat from province to province, they all have the general mission of providing technical support for industries in their province. As the provincial Councils have been the object of one of the Science Council's background studies in this series[13], no more need be said of them here.

Federal Incentives and Grants for Research in Industry

In order to encourage companies to do more research, the Federal Government has instituted a number of incentive and grant programs over the past decade. Although contracts for research related to defence and certain special tax concessions for research had existed prior to 1961, that year marked the beginning of significant and systematic federal participation in the funding of industrial research. There are now six programs, and the total value of their awards to industry in fiscal year 1971-72 is expected to reach $95.0 million.

The Defence Industrial Research (DIR) Program:

This program was instituted in 1961 by the Defence Research Board in order to build up the technological competence within the Canadian defence industry so that it could compete more successfully for defence markets. Under this program, the government will pay about half the cost of approved projects. In order to be approved, projects must have a defence interest as well as technological merit.

[13]Andrew H. Wilson, *Research Councils in the Provinces: a Canadian Resource*, Science Council of Canada Special Study No. 19, Information Canada, Ottawa, 1971.

The Industrial Research and Development Incentives Act (IRDIA):
This program is the successor to a General Tax Incentive Program for research which was first initiated in 1962. Under the old program, 100 per cent of both current and capital expenditures for research could be deducted from income for the year in which they were incurred; in addition, the amount by which the expenditures for the year in question exceeded expenditures in 1961 (the "base-year") was eligible for an additional 50 per cent deduction from income. In 1967 the program was changed to the one now in force in order to permit companies with no taxable income in the year to take advantage of it. Under the present IRDIA Program, Canadian companies may receive a cash grant, or a credit against their federal income tax, amounting to 25 per cent of: (a) all their capital expenditures (other than land) for scientific R & D in Canada; and (b) the increase in their current expenditures in Canada for scientific R & D over the average of such expenditures in the preceding five years. When a company has a project with DIR or some other grant program, the IRDIA grant can be applied only to the company's share of its cost.

The Industrial Research Assistance Program (IRAP)
This program has been in existence since 1962, and it is administrated by the National Research Council. Like the DIR program, it will cover about 50 per cent of total costs, usually the salaries or wages of scientists, engineers and technicians employed on the project. Unlike DIR, however, there is no "defence interest" requirement. This program has been "research"- rather than "development"-oriented.

The Defence Industry Productivity (DIP) Program
The principal objective of DIP is to make Canadian defence industry more productive in order that it might compete successfully on world markets. As such, it is concerned with providing support to modernize and expand production facilities, as well as with supporting development programs themselves. Among the activities which it will support are many non-research technical activities essential to innovation (e.g., product engineering, production engineering and pre-production expenses).

The Program for the Advancement of Industrial Technology (PAIT)
PAIT does for civilian products what DIP does for military products. When first initiated in 1965, the program provided up to 50 per cent of the costs of a project in the form of a loan payable from profits realized from the project. However, the effective interest rate on the loan and other features of the program were such that industry in general was not interested by it, and appropriated funds went begging for clients. This situation was corrected in 1970, when the loan was replaced by a grant and the scope was broadened to include product and production engineering costs. The program now appears to be very successful (if applications are taken as a measure of success).

The Program to Enhance Productivity (PEP)
This is the latest addition to the programs intended to encourage inno-

vation in Canadian industry. It was introduced in 1971. PEP offers a grant of up to $50 000 or up to 50 per cent of approved costs, whichever is least, to cover the costs of studies which have the potential to lead to high-productivity improvement projects.

The total value of all these programs in 1972 is expected to be $95 million, which represents just over 25 per cent of total industrial R & D. The breakdown by program is given in Table III.20.

Table III.20–Federal Support of Industrial R & D

Program	Estimated 1972 Expenditures in Millions
DIP	26.0
PAIT	25.1
DIR	4.5
IRAP	8.4
IRDIA	31.0
Total	**95.0**

Source: Federal Government Expenditures on Scientific Activities, Statistics Canada, Catalogue no. 13 202.

The overall impression which we received from industry concerning these programs was very favourable. Most companies were pleased that the programs existed, and most had found those responsible for their application understanding and helpful. The two principal points receiving some criticism were the growth-orientation of the IRDIA program and the difficulty the "little man" has in finding his way into the system and getting support.

The IRDIA program was intended to induce companies to develop their research facilities rather than to support ongoing work. It is therefore clearly growth-oriented. If a company did no research during the previous five years, its cost of research during the current year would be reduced by 50 per cent (as the grant is not considered taxable income); but if its average expenditures in the previous five years were equal to or greater than those in the current year, its cost of research would not be reduced at all. For a company whose current expenditures on research are rising at a constant rate of 10 per cent per year, the effective reduction in costs of doing research is of the order of 15 per cent.

This "growth encouragement" feature of IRDIA was very frequently criticized by company representatives during our company visits. Although the formulation of the criticisms varied somewhat, they can basically be reduced to the two following points:

1. The scheme is unfair, in that it provides less assistance for the company which has been doing research consistently over a long period than it does to the one that had previously been doing none.

2. The scheme provides the least support in difficult times, when growth of research must be temporarily suspended and assistance would be most needed. In fact, a company which has been increasing R & D and then ceases to do so will continue to see its *net cost* of R & D increase for five years, as the IRDIA support fades out. This, in the eyes of some, invites

companies to cut back in total R & D expenditures in difficult times, in order to keep their *net* expenditures constant.

These criticisms touch the very philosophy of the federal incentive programs. By implication, they are saying that what is needed is continuing federal support for research rather than schemes that encourage industry to enter into, or to increase their level of, research and development. Most of the incentive programs originally assumed that companies, once they had started to do research, would recognize that R & D expenditures were a good investment and would continue to support research from their own resources. The behaviour of Canadian industry in recent years casts considerable doubt on the validity of this assumption. We should now frankly ask the question whether or not government should offer continuing support for research and development in industry. Some of the other programs (DIR, IRAP, PAIT etc.), by being renewed year after year with the same companies, are in fact being used almost as continuing support programs.

The second main area of criticism of these programs concerned the difficulties that are encountered by the small company seeking support. Many small companies, mostly Canadian-owned, complain of having to incur the costs of going to Ottawa, of not knowing just where to go, and of the complexity and time needed to fill the forms, etc. In response to the author's inquiries on these points, the Department of Industry, Trade and Commerce maintained that its personnel would visit the company if it just wrote, that there was thus no need for the company to come to Ottawa, that all the details of the program were explained in detail upon request, and that Industry, Trade and Commerce personnel would practically "hold the hand" of small industries while they wrote the proposal. But small industry does not agree. They counter that they are often passed on to ineffective junior officials, and that the lost time and disruption incurred in obtaining a grant often makes the small grant that they might obtain scarcely worthwhile. Clearly, this is an area where there is need for improved communications between industry and government.

Another point that must be made about these programs is that they offer *no* help for the inventor who does not have an established business record, regardless of the merits of his invention. This lack of support encourages inventors to sell out or to licence to established companies. As the purchasers are often foreign companies, many of the potential benefits can be lost to Canada in this way.

On balance, however, the "battery" of research incentive and grant programs is impressive. In terms of available government support for purely *commercially oriented research and development*, it is unmatched in the western world. Much has been made of the fact that in Canada industry funds a larger relative proportion of its research than in Sweden, the U.K., France and the U.S.A. This could, however, be regarded more as a reflection of the priorities Canada has selected than of a disinterest in economic development. The great bulk of government expenditures for science in the industrial sectors in Sweden, France, the U.K. and the U.S.A. has been for defence and projects of national prestige. If these are taken out, then the government funding of industrial research in these countries is proportionally no greater than in Canada.[14] In Canada, our only real project in big science has been our nuclear energy program, and this has been conducted within the public sector. It has been a contributing factor in our relatively large expenditures on in-house R & D.

In its recent report[15], OECD classifies Canada as the country that has most stressed economic development in its R & D funding. This is illustrated in Table III.21, which shows government expenditures directed toward economic development as a percentage of GNP.

Table III.21–Government Expenditure on Economic Development as a Percentage of GNP

Country	1961	1965	1968
United Kingdom	0.15	0.17	0.28
Japan	0.13	0.14	0.12
Netherlands	0.13	0.17	0.19
Norway	0.12	0.21	0.23
Sweden	0.07	0.10	0.12
France	0.07	0.14	0.21
United States	0.07	0.10	0.11
Belgium	0.07	0.08	0.11
Canada	0.19	0.28	0.36

Source: OECD report, SP (71) 10, 1971.

It is true that "big science" projects of defence and aerospace have considerable economic spin-off, and that the industries of the U.S., the U.K. and France have benefited considerably from them. This does not, however, detract from the fact that the intent of this funding was defence or prestige, as the case may be, and not primarily economic development. In view of this, we cannot fault the Federal Government too much for its policies toward R & D funding in industry. This is not to imply that the Federal Government bears no responsibility for the unhappy state in which secondary manufacturing finds itself; it most certainly must be held responsible for the industrial climate in Canada. There is very little *evidence*, however, that it is primarily its R & D support policies that are at fault.

Industry as a Performer of R & D

Despite an obvious desire on the part of the federal government to stimulate R & D in Canadian industry, Canada remains one of the very few countries in which less than 50 per cent of the total national R & D effort is made in the industrial sector. The most recent international comparisons available on the subject are those given in the OECD Report.[16] The data, which are for the year 1967, are reproduced in Table III.22.

Spain (44.6%), Ireland (35.4%), Greece (33.5%) and Portugal (16.1%) are the other countries in which the industrial sector is responsible for less than one-half of the R & D. We should note, moreover, that in Spain, Ireland and Greece the shift during the period 1963 to 1967 has been toward more R & D performed in the industrial sector. Canada and

[14] OECD Report, SP (71) 10, 1971.
[15] *Ibid.*
[16] *Ibid.*

Table III.22–GERD in OECD Member Countries, by Sector of Performance, 1963 and 1967

Country	Business Enterprise		Government		PNP*		Higher Education		GERD
	1967	1963	1967	1963	1967	1963	1967	1963	%
Austria	63.4	63.5	9.0	9.5	0.1	1.0	27.5	26.0	100.0
Belgium	66.8	69.0	10.4	9.8	1.3	1.3	21.4	19.9	100.0
France[a]	53.1	48.9	31.8	35.9	1.0	0.5	14.1	14.7	100.0
Germany[b]	58.2	66.0	5.1	3.4	10.4	11.0	16.3	19.6	100.0
Greece[b, c]	33.5	15.8	44.4	74.1	1.3	0.9	20.7	9.4	100.0
Ireland	35.4	29.1	48.9	56.7	1.1	3.6	14.6	10.6	100.0
Italy	60.6	62.1	28.2	23.5	0.0	0.0	11.2	14.4	100.0
Japan[a]	54.0	56.3	10.3	11.0	3.1	3.6	32.7	22.1	100.0
Netherlands[b]	58.1	59.5	2.7	2.8	17.7	21.1	21.5	20.6	100.0
Norway	50.0	51.2	16.1	21.0	1.1	2.3	32.8	24.9	100.0
Portugal[b]	16.1	22.1	69.4	66.3	7.1	5.3	7.4	6.3	100.0
Spain[b]	44.6	25.2	52.8	68.4	—	—	2.7	16.4	100.0
Sweden[b]	69.9	69.2	14.2	16.1	0.4	0.4	15.5	14.3	100.0
United Kingdom[b]	64.9	65.3	24.8	24.9	2.5	2.5	7.8	7.3	100.0
United States[a]	69.5	70.3	13.8	14.8	3.6	3.3	13.1	11.6	100.0
Canada	37.7	39.7	35.6	40.4	0.0	0.0	26.7	19.9	100.0

*PNP = Private non profit.
[a]Including the Social Sciences and Humanities in France and Japan, and the Social Sciences in the U.S.
[b]For 1963 read 1964
[c]For 1967 read 1966
[d]For 1969 read 1968 or 1968/69
Source: OECD Report, SP (71) 10, 1971.

Portugal are the only two countries who already have a low proportion of R & D performed in the industrial sector, and for whom this trend became more pronounced in the period 1963 to 1967. The most disturbing aspect of this comparison is that it was made in the period when industrial research in Canada was performing at its best. Indeed, as will be shown in subsequent paragraphs, industrial research and development in Canada increased quite rapidly from the early 1960s, when government incentive programs were first established, to its peak in about 1967 or 1968.

It has been pointed out by Lamontagne[17] and others that Canada does relatively more research and less development than most other countries. While most industrialized countries spend two-thirds of the R & D dollar on development, Canada spends only about one-third. This, in our view, is not a cause of the problem, but simply the reflection of the low percentage of R & D which is performed in industry. It is characteristic to most countries that universities do mainly research, particularly basic research, while government laboratories do mainly applied research, with lesser amounts of basic research and development; in all countries industry carries out the bulk of the development.

The Evolution of R & D in Industry

In the early 1960s industrial research and development in Canada, which had been growing quite slowly, began to respond to the incentive schemes being offered by the Federal Government. New research laboratories began to open in many companies where none had existed before, and the existing laboratories grew rapidly larger. This trend gained momentum during the first half of the 1960s, reaching a peak in 1965, when a new laboratory was established in Canada every six days.[18] Between 1965 and 1968, there continued to be substantial growth in the total R & D activity in industry, although the number of new laboratories had fallen back to what it had been in earlier periods. Beyond 1968, the level of industrial research and development appears to have remained about static. In most recent times, it appears to be declining in absolute magnitude.

This levelling off and subsequent decline of research and development activity in industry has taken place at a time when the federal government has a deliberate policy of encouraging a shift from in-house government R & D to more performance in the universities and in the industrial sector. It was at the beginning of the 1960s that research funding was rapidly increased, for universities through the National Research Council, and for industry through the Department of Industry, Trade and Commerce, the National Research Council and the Defence Research Board. Initially both the universities and the industrial sector responded to these incentives, although the response of the industrial sector was never as pronounced as that of universities. (Even in the early periods, some of the funds available in government programs were not fully utilized.) By 1968, industry had apparently decided that, government grants or no government grants, it was doing enough research and development. A number of the smaller

[17]Canada, Senate Special Committee on Science Policy, *op. cit.*

[18]Frank Kelly, *Prospects for Scientists and Engineers in Canada.* Science Council of Canada Special Study No. 20. Information Canada, Ottawa, 1971. p. 58.

Table III.23—Capital and Current Intramural R & D Expenditures by Canadian Manufacturing Industries (Millions of Dollars)

Industry	1963	1964	1965	1966	1967	1968	1969	1970
Electrical Products	38.5	48.8	63.0	71.5	95.2	89.7	102.6	102.6
Aircraft and Parts	31.4	40.8	54.6	51.2	40.6	43.6	50.0	
Chemicals and Chemical Products	27.1	35.9	38.7	41.0	46.2	45.1	51.1	56.5
Paper	15.0	20.1	25.2	25.7	25.8	23.1	23.6	24.4
Petroleum Products	11.2	18.2	22.7	21.5	20.7	23.3	22.8	15.7
Primary Metals (Non Ferrous)	10.9	10.4	11.5	14.2	20.1	16.5	21.5	24.1
Machinery	6.8	8.1	8.4	9.6	14.2	16.9	18.6	19.8
Food and Beverages	4.9	6.0	7.2	8.3	9.0	10.0	10.0	11.0
Scientific and Professional Instruments	5.2	5.6	7.7	8.2	9.3	9.2	11.4	10.8
Primary Metals (Ferrous)	3.7	7.0	7.7	7.0	6.3	6.4	7.0	8.0
Textiles	2.8	3.4	4.4	3.7	4.2	4.7	5.0	5.6
Metal Fabricating	4.0	3.6	3.6	3.4	3.2	4.4	5.3	5.0
Rubber	2.0	2.4	3.0	3.3	3.7	4.1	4.4	4.8
Non Metallic Mineral Products	2.1	2.0	1.9	2.9	3.0	3.3	3.6	4.2
Other Transportation Equipment	.7	1.9	2.0	1.9	4.8	5.2	8.7	
Wood	.2	.2	.3	.3	1.3	.8	.7	.7
Furniture and Fixtures	.1	.1	.1	.1	.2	.2	.4	.4
Total Manufacturing	**169.1**	**218.1**	**266.3**	**279.8**	**310.6**	**310.4**	**351.1**	**344.9**

Source: DBS, "Industrial Research and Development Expenditures in Canada", Catalogue Nos. 13-527, 13-203.

laboratories that had emerged in the early 1960s closed their doors in the late 1960s. The years 1970 and 1971 saw some of the larger, well-established companies, particularly in the chemical and chemical process industries, cut back severely on research or close laboratories completely. Chemcell, Gulf Oil and Consolidated-Bathurst are examples of companies closing laboratories, while industrial leaders such as Polymer, DuPont and McMillan Bloedel have effected large-scale cut-backs.

In order to better understand some of the reasons for the opening and subsequent closing of some of the smaller laboratories, it is necessary to understand something about the economics of the government incentive programs. As was indicated earlier, these programs were geared to encourage growth of research and development, rather than to sustain existing operations. Under the programs that were available, a company entering into research for the first time and having a project that was approved for support under IRAP or DIR could, by also taking advantage of IRDIA (or its predecessor), initially do its research for 25 cents on the dollar before taxes. If one considers that the 25 cents spent on research would have been profit, taxable at about 50 per cent, the net after-tax cost to the company was only 12½ per cent. Although this may appear to some to be a somewhat unorthodox way of calculating costs, the R & D programs were very frequently presented to companies in precisely those terms (i.e., as research costing 12½ cents on the dollar). Moreover, all of the normal overhead costs were allowed as part of the company contribution to the research project. Thus, a firm that had some unused space which could be converted into a research laboratory could undertake research at a very small incremental cost. Companies that already had research laboratories found little support for their on-going operations. However, if they wished to expand their research, they could do so for the same incremental costs (i.e., 25%) as the firm just undertaking research. Having become accustomed to paying $1 for a dollar's worth of research, and having the opportunity to do an additional dollar's worth of research for 25 cents, proved a strong inducement to these companies to expand. The incentive schemes, then, proved very successful, in that they promoted the opening of new research laboratories, and they encouraged expansion of research in existing laboratories.

Another factor that contributed to the rapid rise of R & D expenditures in the early 1960s is the change in accounting that took place in industry, when it became recognized that there were tax benefits to be gained by considering a given activity as research. Many borderline activities, between development and engineering or between development and quality control, were now moved into the research laboratory, where they *became* development, and thus eligible for IRDIA support. In many instances, these activities had clearly been development all along, but had never been recognized as such; for others a little polishing was required in order to pass the scrutiny of government auditors. This "re-naming" of existing activities no doubt served to raise R & D statistics artificially.

When the newly formed laboratories began to stabilize their levels of activity, they found that their cost did not also stabilize. The proportion of the total activity that had to be paid for by the company increased as the

IRDIA support, which was based on growth, began to decrease. The incentive schemes had made growth easy; they had postponed but not eliminated the cost of research and development.

Thus, the phenomenon of rapid rise in industrial research expenditure in the early 1960s, and its subsequent decline at the end of the decade, may reflect more the high degree of success of the incentive scheme in the early stages than its failure at the present time. The philosophy for setting up the incentive programs in the first instance had been that research and development would be beneficial to Canadian industry and, if given a chance to take root, it would prove its worth and be self-sustaining. The fact that growth has now ceased and that there are cut-backs in many laboratories proves that many Canadian companies do not share the view that research is a good investment in their case. Since these decisions are being taken by companies that have experienced research, it would be very presumptuous on our part to assume that they are wrong.

Since intuitively we would expect successful innovation to be considered desirable by most, if not all companies, and since research and development is the first step toward innovation, we must ask ourselves why there is this reluctance to spend money on trying to get the innovative process started. This reluctance to invest in R & D cannot be ascribed primarily to a lack of money, for Canadian manufacturing industry invests a larger portion of its return in plant and equipment than does industry in the United States. This is illustrated by the data presented in Table III.24, which shows that, while Canadian Manufacturing industries in general spend a larger proportion of the sales dollar on capital plant and equipment than do their American counterparts, their expenditures on R & D are proportionately only a fraction of those in the U.S. There are factors other than a shortage of money, then, which impede the process of innovation to the extent of making the first step toward it scarcely worthwhile. Perhaps Canadian industry simply does not see innovation as part of its role.

Table III.24–Comparison of Capital Expenditures and R & D Expenditures by Industry in Canada and the U.S.A., 1970

Industry	Country	Capital Expenditure as % of Sales	R & D Expenditure as % of Sales	Ratio (R & D Expenditure / Capital Expenditure)
Electrical and	U.S.	4.5	8.5	1.8
Electronic	Canada	4.0	4.0	1.0
Chemical	U.S.	7.1	3.7	.52
	Canada	9.9	2.4	.24
Manu-	U.S.	4.9	2.6	.53
facturing	Canada	7.0	.87	.12
All Business	U.S.	6.3	1.4	.22
	Canada	13.9	.47	.03

Sources:
–*Canada Year Book, 1970-71*, Statistics Canada, Information Canada, Ottawa, 1971.
–DBS: "Private and Public Investment in Canada, Outlook and Regional Estimates", Catalogue No. 61-205; and "Industrial Research and Development Expenditures in Canada", Catalogue No. 13-203.
–U.S. Department of Commerce, *Survey of Current Business*, Washington, January 1972.
–*19th Annual Survey of Business Plans for R & D Expenditures 1972-75*, McGraw-Hill, New York, 1972.

IV. The Incentive to Innovate

The Ingredients for Effective Use of Science and Technology

In a free enterprise economy such as Canada's, the principal agent for the application of science and technology toward the achievement of economic objectives is the private sector. This does not imply that universities and governments do not have important roles in harnessing scientific and technological knowledge for the benefit of the nation; however, their activities are less immediately directed toward economic objectives, and relatively more oriented toward those benefits containing more cultural and social components. Universities, as the generators of new knowledge and as the principal distributors of basic scientific and technological information, provide the foundations upon which to build the nation's technological capability. Governments, through the policies which they establish (or fail to establish), are the principal agents for establishing the climate in which innovation and science-based industry will flourish – or wither. Moreover, governments and universities are the principal agents for innovation in those areas, such as health, where the social considerations are of prime concern and where the private sector does not possess the organization for effective action.

If innovation and the effective use of science and technology are to occur in the private sector, two essential conditions must be met: industry must have the *incentive* to innovate and to develop in science-intensive areas; it must, moreover, have the *capability* of doing so.

In our Western free enterprise society, the principal incentive motivating industry is the expectation of profit. Innovation implies considerable expenditure, compounded by risk; those expenditures will be incurred, and the risks taken, only if management estimates that a net profit will likely result. The relative underdevelopment of science-based manufacturing in Canada and our poor record for innovation are in themselves indications that these activities may not be financially attractive in Canada.

This suspicion tends to be confirmed by the actions of the Canadian investor, who is not attracted by Canadian science-based manufacturing despite the fact that, on a world basis, the science-based industries have been experiencing the fastest growth rates and yielding some of the highest returns. In this respect it is interesting to consider the 100 most popular stocks, in dollar value of sales, on the Toronto Stock Exchange. Of the total, 96 are stocks of companies incorporated in Canada (not necessarily Canadian-owned) and the remaining 4 comprise 3 U.S. corporations and one British. It is interesting that 2 of the 4 non-Canadian companies are highly science-intensive (IBM and Rank Xerox), one is moderately science-intensive (General Motors) and only one is a resource-based company (Pan Ocean Oil Corporation). By contrast, not one of the 96 Canadian-incorporated companies could be classified as highly science-intensive, and only 3 (Moore, Massey Ferguson and Ford) are moderately science-intensive manufacturing companies. Moreover, the 2 Canadian-owned companies in the "moderately science-intensive" category conduct more than 90 per cent of their business outside Canada, while the foreign-owned one (Ford Motor Company of Canada) conducts only 40 per cent of its business outside the country. Furthermore, both Moore and Massey

Ferguson do the bulk of their research, development and engineering outside of Canada, while Ford gets almost the totality of its technology from its parent, Ford Motor Company (U.S.). In terms of their activities in Canada, then, even these three can scarcely be classified as "moderately science-intensive". Most of the remaining 93 companies most favoured by Canadian investors are in the service and resource-development sectors, as seen in Table IV.1.

Table IV.1–Distribution of the 100 Most Traded Stocks on the Toronto Stock Exchange, by Type of Industry[a], 1971

Type of Industry[b]	Companies Incorporated in Canada	Companies Not Incorporated in Canada
Secondary Manufacturing	3	3
Oil and Mining Companies	45	1
Services and Utilities	35	0
Primary Metals and Resource-Based Manufacturing[c]	7	0
Food, Beverages, Tobacco	6	0
Total	**96**	**4**

[a]*Source: Top Hundred. A Guide to 100 Canadian Stocks.* Compiled by the editors of Financial Times of Canada, Montreal, 1972.
[b]Companies engaged in more than one sector were classified according to the sector from which they derived the largest portion of their profits.
[c]Includes pulp and paper.

In summary, when Canadian investors put their money into companies operating mainly abroad, they seem to favour manufacturing companies with moderate-to-high technology dependance, but when they invest in companies that depend on the Canadian environment, they will overwhelmingly favour resource-based industries and services.

On the basis of the foregoing, one might readily conclude that secondary manufacturing, and particularly science-based manufacturing, is simply a bad investment in Canada and let the matter rest there. Other evidence, however, appears to contradict this simple hypothesis.

The first indication we have that Canadian manufacturing may be considered by some as a good place to invest comes from the high capital-intensity which characterizes it. As is seen in Chapter II, Canadian manufacturing attracts more capital per job than its U.S. counterpart.

A second indication of its potential attractiveness comes from the attitudes of multinational corporations. These are generally considered to be wise investors, and their phenomenal growth during the past two decades would tend to confirm it. On the basis of their attitudes toward investments in Canada, one must conclude that Canada is the world's most profitable country in which to invest. Of a total of $89.6 billion invested by multinational corporations throughout the world to the end of 1966, Canada was the recipient of $34.7 billion, or nearly 40 per cent of the total.[1, 2] Of equal interest is the sector of industry into which this capital has been channelled in Canada. Like the Canadian investor, the foreign investor likes to place his money in mines and oils (37.7% of total foreign

[1]OECD, DAC (68) 14, 23, April 1968. Page 28.

[2]*Canada Year Book 1970-71*, Statistics Canada, Information Canada, Ottawa, 1971. Pages 1205, 1206.

investment). Quite in contrast to the Canadian investor, however, he considers secondary manufacturing to be the best investment of all (41.5% of the total), while services and utilities are relatively lower in his priorities.

By his actions, the foreign investor seems to be saying: "Canadian manufacturing is the most profitable sector, in the most attractive country for investment in the world". How can we reconcile these sharply contrasting attitudes of foreign and Canadian investors? Who is wrong? Or, are they both right? Indeed, there is good reason to believe that both *are* right. As will be seen later in this chapter, there is considerable evidence to suggest that Canadian manufacturing industry has been permitted to evolve into a state that indirectly discriminates against the indigenous manufacturer. The manufacturer who attempts to innovate in Canada and who strives to develop and use his own technology – whether he is the independent Canadian manufacturer who has little alternative but to rely on his own technological resources, or the foreign subsidiary who attempts to be a "good corporate citizen" – will frequently find himself at a disadvantage in comparison to his counterpart in the industry who ties into a "technology pipeline" sourced outside of the country. With the highly fragmented and limited markets available to manufacturers in many areas, the only viable option is often a limited degree of manufacturing from designs, specifications and components imported from abroad. For an international corporation, this can be profitable; for the nation, it can have disastrous consequences in the long term.

The Importance of Demand

In the course of our interviews with industrial leaders, one of the most frequently mentioned impediments to innovation in Canadian manufacturing industry and to its ability to develop competence in the use of science and technology was the limited markets available in Canada. It was pointed out, moreover, that a good home market is essential to innovation, and that only in the most exceptional cases can new products be launched on export markets. Normally, new products and new processes are developed to serve domestic markets, and exports follow after the companies have achieved a degree of proficiency from their experience at home. The executives interviewed emphasized the limited size of the market rather than its lack of sophistication. The points that emerged as the principal features of the limited market available to Canadian manufacturers were the following:

a) the intrinsically small size of the Canadian market due to our small population;

b) the tendency for Canadians to import such a large proportion of their manufactured products;

c) the excessively large number of suppliers for most products, considering the size of market available;

d) the fact that Canada does not belong to a "trading bloc";

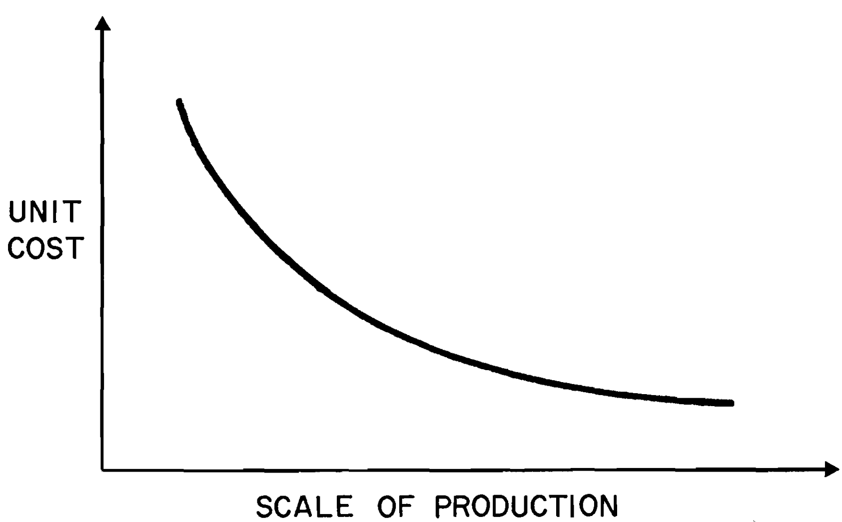
e) restrictions on access to foreign markets imposed upon subsidiaries by their parents.

No attempt has been made to place the above in order of importance, as the executives to whom we spoke were far from being unanimous among themselves.

This emphasis on the importance of markets and demand to the process of innovation is consistent with the empirical results of studies on the relative importance of market need and technological opportunity as stimuli to innovation. According to the four studies reported by Keith Pavitt in "The Conditions for Success in Technological Innovation"[3], between 66 and 77 per cent of innovations result from the "demand-pull", of the market, rather than the "technology-push" of technological opportunity.

Fundamental to this question is the concept of economies of scale, which states that a product costs less to produce in large quantities than it does to produce in small quantities. There are several reasons for this, some of the principal ones being: fixed costs, such as those of development, can be amortized over a large volume of production; more efficient means of production can be afforded; production runs are longer, resulting in relatively less time lost in equipment "set-ups"; it is possible to achieve a greater degree of labour specialization. In general, the reduction of costs with increasing volume is not linear; rather, it falls very sharply at first and then less rapidly as volumes increase. Typically, it has the form shown in Figure IV.1.

Figure IV.1–Typical Form of the Cost-Versus-Scale Curve for a Manufactured Product



The precise shape of the curve and its slope at any given point will depend on the product, the method of manufacture and many other parameters. Some idea of the magnitudes involved can be given by considering a specific example. In the study by the Royal Commission on Farm Machinery, a detailed analysis was made of the unit costs of producing a

[3]Keith Pavitt, *The Multinational Firm and the Transfer of Technology*, Second Draft prepared for a Conference on the Multinational Enterprise, University of Reading, Berkshire, May 1970.

tractor at various production levels. The study group reported the following estimates of unit manufacturing costs for three postulated levels.

Table IV.2–Influence of Scale on Manufacturing Costs

Production Level	Manufacturing Cost	Saving in Comparison with the Lowest Postulated Production Level
Units per year	Dollars	Percentage
20 000	3 875	
60 000	3 412	12
90 000	3 121	19.4

Source: Canada, Royal Commission on Farm Machinery, Study No. 2, *Farm Tractor Production Cost*, Queen's Printer, Ottawa, 1969.

As this evaluation illustrates, very appreciable economies of scale are possible for this product in the range of 20 000 to 90 000 units. The pattern for other manufactured products of this type (e.g., appliances, machinery, etc.) is not unlike what has been shown here for tractors. In general, the economies of scale are proportionately more important at levels of production below 20 000 units per year, whereas at volumes in excess of 100 000 their importance is somewhat diminished. They can be significant, however, even at levels of millions of units per year. In the example given above, only the manufacturing costs were taken into account. For a complete picture, the non-manufacturing elements of cost should be added and distributed on a per-unit basis. These would include the costs of corporate administration, marketing, advertising, distribution, research and development, and a number of other costs which, for some products, can equal or surpass the manufacturing costs themselves. Some of these are variable costs (i.e., approximately proportional to the volume of production), while others are fixed costs (i.e., independent of the level of production). Because the proportion of these fixed costs is high, adding them to the manufacturing costs normally has the effect of making the unit cost even more sensitive to scale.

A related concept which is widely used in manufacturing industry is the "learning curve".[4, 5, 6] In its most elementary form, the learning curve is based on the observation that the time required to perform a manual operation is reduced by a constant factor (say, by 20%) for each doubling in the number of times the task is repeated. This phenomenon has been observed for a wide variety of manual operations such as those encountered in manufacturing. The concept is used to some extent in this very rudimentary form to project future manufacturing costs as volume increases and as experience is gained in the manufacture of products depending largely on manual operations. Moreover, the concept has been found to be generally applicable in partially or totally automated operations, as well as in those that rely heavily on manual labour. In this latter context, it implies that there is a process of "learning" on the part of those responsible for

[4]Patrick Conley, "Experience Curves as a Planning Tool", *IEEE Spectrum*, June, 1970.

[5]W.B. Hirsham, "Profit from the Learning Curve", *Harvard Business Review*, Vol. 42, 1954. Page 125.

[6]F.J. Andress, "The Learning Curve as a Production Tool," *Harvard Business Review*, Vol. 32, 1954. Page 87.

conceiving, developing and controlling production technology. Most manufacturing operations on which this concept has been tested have involved situations in which the rate of production was increasing; thus, economies of scale as well as a cumulative increase in the experience were involved. For this reason, it is difficult to sort out how much of the gain is due to "learning" and how much is due simply to "production volume". In most practical cases, it is not important to have a quantitative assessment of the value of each, but from a policy point of view, it is important to recognize that both phenomena have an effect. Both imply that a substantial volume of production (and, thus, an adequate market) is essential for the achievement of a competitive position, assuming of course that comparable products are manufactured and that fundamentally the same production technology is used.

Market Sophistication

The "learning curve" concept, however, goes beyond the simple "economies of scale" concept by implying that it is important to enter a field early and to develop it quickly, in order to gain the advantage of "cumulative experience". It is for this reason that the sophistication of a nation's market is of prime importance for the development of that nation's high technology industry. This sophistication is reflected at various levels. The most obvious is of course the level of the finished product, although it is doubtful whether this is the most significant level. Finished products are made from sub-assemblies, sub-assemblies from parts, and parts from materials. The sophistication of the market, as seen from the parts manufacturers' and the materials producers' points of view, is likely to be the more important to innovative performance, for it is at these levels that important innovations appear most likely to originate.[7]

The Canadian market, as will be seen in subsequent paragraphs, has been and continues to be a sophisticated market from an "end-product" point of view. But, for reasons to be elaborated on in more detail later in this report, it is unsophisticated from component and material viewpoints. By way of example, consider the field of electronic computers. This market developed early in Canada, and it continues at relatively high levels by world standards today. But computers are made of integrated circuits, transistors, memory cores, capacitors, and a multitude of other parts. Because no computers are designed in Canada, the level of sophistication in regard to these components is comparatively low. If a Canadian manufacturer is to supply these parts at all, it will be in conformity to the specifications previously worked out between the computer manufacturer and a component manufacturer in the country where the computer was developed (a competitor or a parent). The options open to the Canadian manufacturer will be to copy or not to supply; to innovate will not be an option. Moreover, before the market is truly existent in Canada, the foreign competitor will have had time to move well down on his learning curve, making even copying a doubtful proposition.

[7]OECD, *The Conditions for Success in Technological Innovation*, Paris, 1971.

Without the sophisticated market for components, there can be no sophisticated market for the high-purity silicon of the transistors, the highly specialized tantalum powder of the capacitors, the finely finished ceramic substrate of the integrated circuits, or any of the hundreds of other high-technology materials that underpin this industry. The reader's attention is brought to Table A.7 (page 132), which shows how badly we lag in advanced electronic components.

The Size of the Canadian Market

As it was mentioned earlier in the text, the intrinsically small size of the Canadian market has been frequently mentioned as a major impediment to innovation, and to the development of secondary manufacturing. This point merits more detailed examination.

Canada, with a GNP of $80.2 billion in 1970, ranked as the seventh largest of the industrial countries in non-communist world. As can be seen from Table IV.3, the largest country (the U.S.) had a market more than five times larger than the second largest (West Germany), but subsequent differences in size are very much smaller. The next six countries (West Germany, Japan, France, the United Kingdom, Italy and Canada) have GNPs that differ by just a little more than a factor of two from the largest to the smallest. Following these we find Australia, Sweden, Spain and the Netherlands, all of similar size, and with GNPs about two-and-one-half times smaller than that of Canada. (Sweden and the Netherlands performed very well despite their small size, according to the OECD study.) In a world perspective, therefore, Canada's market assessed according to GNP is modest but not "very small". In the perspective of the North American continent, however, it is dwarfed by the enormous market of our southern

Table IV.3–GNP in Current Prices for Some Non-Communist Countries, 1970

Country	$ Million
U.S.	974 220
W. Germany	187 050
Japan	167 200*
France	148 230
U.K.	121 180
Italy	92 850
Canada	80 160
Australia	35 850
Sweden	32 560
Spain	32 260
Netherlands	31 280
Belgium	25 880
Denmark	15 570
Switzerland	18 880*
Austria	14 370
Turkey	12 560
Norway	11 390
Finland	10 220
Portugal	6 250

*1969

Source: The OECD Observer, February 1972. 56:19.

neighbour. It is in this latter perspective that many Canadian businessmen see Canada.

The demand for the products of science-based industry is not of course related simply to GNP, but it is likely to be enhanced in countries that have a high per capita income. In this latter respect Canada ranked third in 1970, behind the United States and Sweden. In terms of high-technology products, taking this factor into account has the effect of accentuating even more the already very large differences between our market and that of the U.S. On the other hand, it reduces the significance of the differences between ourselves and Japan, West Germany, France and the United Kingdom.

There are several other parameters that can be used as broad indicators of demand for certain classes of manufactured products. For example, the output of electrical power – or better still, its rate of growth – will generally reflect the demand for electrical products (electricity-producing and electricity-consuming products), and the number of passenger miles flown by airlines of a country is a good indicator of the demand for civilian aircraft.

Figure IV.2 shows a comparison of electrical power generation for a number of the larger OECD countries. From this, it can be seen that Canada is again dwarfed by the U.S.; but, on the other hand, we compare reasonably well with the larger countries of Western Europe. In passenger miles flown per year, we rank in third place among western nations – behind the U.S. and the U.K., but ahead of France, West Germany and Japan.[8] On this indicator, as in so many others, we are at between 7 and 8 per cent of U.S. levels.

In consumer products that have high science and technology contents, we again find the same pattern: less than 10 per cent of the U.S. levels of demand; but, on the whole, comparable to West European countries and Japan. This is seen in Table IV.4, which gives the numbers (in absolute terms) of some consumer products.

Moreover, in many of these products Canada's relative position was much better twenty years ago than it is today. Tables IV.5, IV.6 and IV.7 show comparisons of the absolute numbers of automobiles, television sets

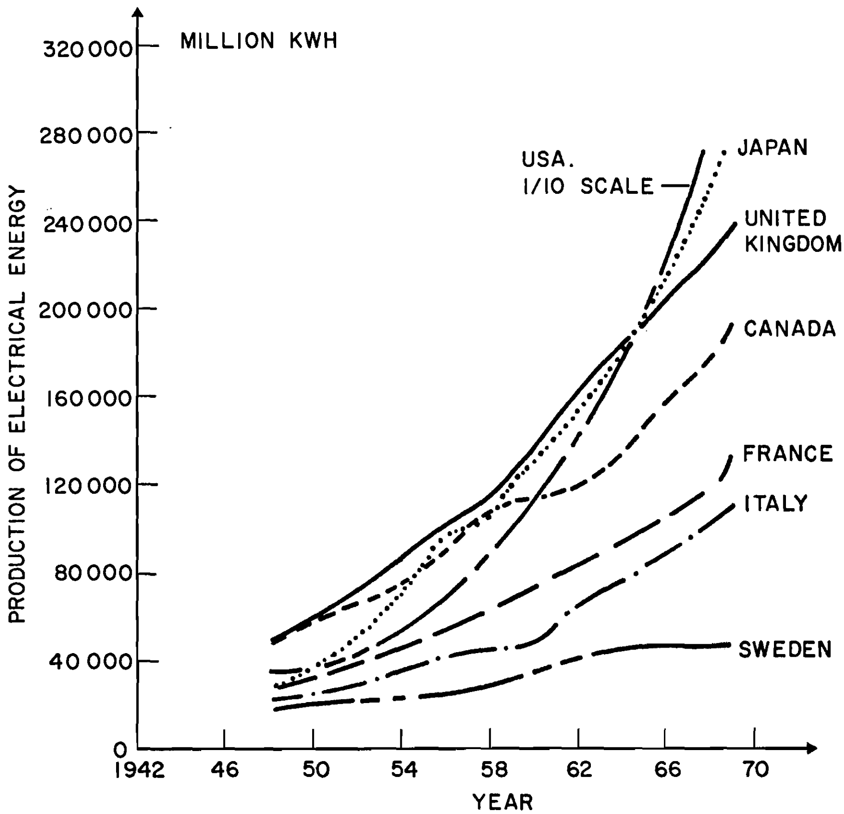
Table IV.4–Distribution of Science-Based Consumer Goods in Some OECD Countries, 1969
(In Absolute Numbers)

Country	Telephones	Automobiles	T.V. Sets*	Radios*
	× 1 000	× 1 000	× 1 000	× 1 000
United States	115 222	86 710	78 000	285 000
Canada	9 303	6 433	6 100	14 100
West Germany	12 456	12 194	14 958	28 000
France	8 116	12 000	9 252	15 558
United Kingdom	14 061	11 365	15 434	17 493
Japan	19 899	6 934	21 027	25 742
Italy	8 528	9 028	8 347	10 976
Sweden	4 111	2 194	2 345	2 927

*1968
Source: United Nations Statistical Yearbook, 1948 to 1970, United Nations, New York, 1971.

[8] *The Monthly Bulletin of Statistics*, Vol. xxv, United Nations, New York, March 1971.

Figure IV.2–Generation of Electrical Energy in Some OECD Countries



Source: The Monthly Bulletin of Statistics, Vol. xxv, United Nations, New York, March 1971.

and telephones in use in various countries between 1947 and 1969. It can be seen from these that Canada was third in telephones and television sets until 1957, and third in the number of automobiles until 1954. Having these markets early gave Canada an opportunity to benefit from economies of scale and learning curves, but we failed to capitalize on this.

In 1970 our market for electronic equipment, at $1.15 billion[9], was comparable to that of U.K. ($1.59 billion) and France ($1.56 billion), and about 40 per cent of West Germany's ($2.58 billion).[10] Specifically in the area of computers and related hardware, the U.K. market for 1970 is estimated at $465 million, that of France at $527 million, and that of Germany at $810 million. Estimates of the Canadian market in the area are made difficult because of the practice of renting computers rather than buying, but it has been estimated that in 1970 Canadians paid about $540 million for computer services[11], of which $290 million was for computer

[9]EIA of Canada, *Electronics Industry: Facts and Information, 1966-1970,* Ottawa, June 1971.

[10]*Electronics,* McGraw-Hill, December 12, 1970.

[11]Estimates based on preliminary data from the Department of Communication "Canadian Computer Communication Task Force" and on a discussion with Dr. W. Little of the Science Council.

Table IV.5–Automobiles: Number Per Capita and in Use (Thousands)

Country		1947	1950	1953	1955	1957	1960	1962	1965	1968	1969
Canada	A.	.11	.14	.17	.19	.20	.23	.24	.27	.30	.31
	B.	1 370	1 907	2 514	2 935	3 383	4 104	4 531	5 279	6 160	6 433
U.S.	A.	.21	.27	.29	.32	.32	.34	.35	.39	.41	.43
	B.	30 719	40 334	46 360	52 136	55 906	61 724	65 649	74 913	83 276	86 710
U.K.	A.	.04	.05	.05	.07	.08	.10	.12	.17	.20	.20
	B.	1 996	2 317	2 798	3 550	4 205	5 542	6 656	9 030	10 949	11 365
Italy	A.	.004	.007	.01	.02	.03	.04	.06	.11	.16	.17
	B.	184	342	613	879	1 238	1 995	3 030	5 469	8 178	9 028
France	A.	—	.04*	.05	.07	.09	.12	.15	.20	.23	.24
	B.	—	1 520*	2 020	3 016	3 972	5 546	7 008	9 600	11 500	12 000
W. Germany	A.	.004	.01	.02	.04	.05	.08	.11	.16	.19	.21
	B.	194	598	1 251	1 813	2 637	4 337	6 124	8 975	11 323	12 194
Sweden	A.	.02	.04	.06	.09	.12	.16	.19	.23	.26	.28
	B.	161	252	431	636	863	1 194	1 424	1 793	2 072	2 194
Japan	A.	.0003	.0005	.001	.002	.002	.005	.009	.02	.05	.07
	B.	20	43	115	153	218	456	889	2 182	5 208	6 934

*1949

A. Number Per Capita

B. Number in Use (Thousands)

Source: "Transport: Motor Vehicles in Use", *United Nations Statistical Yearbook, 1948-1970*, United Nations, New York, 1971.

Table IV.6–Televisions: Number Per Capita and in Use (Thousands)

Country		1951	1953	1954	1955	1957	1960	1962	1965	1968	1969
Canada	A.	—	—	.04	.13	.16	.22	.23	.27	.29	—
	B.	—	—	665	2 000	2 730	3 930	4 375	5 310	6 100	—
U.S.	A.	.10	.17	.20	.22	.27	.31	.32	.36	.39	.40
	B.	15 800	27 300	32 500	36 900	47 000	55 600	59 000	70 350	78 000	81 000
U.K.	A.	.02	.06	.08	.11	.15	.21	.23	.25	.28	.28
	B.	1 162	2 957	4 156	5 400	7 761	11 076	12 231	13 516	15 434	15 792
Italy	A.	—	—	.001	.003	.01	.04	.07	.12	.16	.17
	B.	—	—	35	130	674	2 124	3 457	6 045	8 347	9 015
France	A.	—	—	.002	.005	.02	.04	.07	.13	.18	.20
	B.	—	—	72.2	225	683	1 902	3 427	6 489	9 252	10 121
W. Germany	A.	—	—	.001	.004	.02	.08	.13	.20	.25	.25
	B.	—	—	27.6	200	1 220	4 635	7 213	11 379	14 958	15 970
Sweden	A.	—	—	.00005	.007	.01	.16	.21	.27	.30	.40
	B.	—	—	0.4	5	87	1 167	1 626	2 085	2 345	3 200
Japan	A.	—	—	.00005	.0001	.007	.07	.13	.18	.21	.21
	B.	—	—	5	100	650	6 860	12 612	17 960	21 027	21 879

A. Number Per Capita
B. Number in Use (Thousands)
Source: United Nations Statistical Yearbook, 1948-1970, United Nations, New York, 1971.

Table IV.7–Telephones: Number Per Capita and in Use (Thousands)

Country		1947	1950	1953	1955	1957	1960	1962	1965	1968	1969
Canada	A.	.18	.19	.24	.26	.29	.30	.34	.38	.42	.44
	B.	2 331	2 912	3 620	4 147	4 812	5 433	6 340	7 440	8 821	9 303
U.S.	A.	.24	.28	.31	.34	.37	.41	.43	.48	.54	.55
	B.	34 867	43 004	50 373	56 243	63 621	74 341	80 969	93 659	109 256	115 222
U.K.	A.	.097*	.12	.12	.13	.14	.16	.17	.19	.23	.25
	B.	4 871*	5 376	6 094	6 830	7 300	8 208	8 841	10 621	12 799	14 061
Italy	A.	.02	.03	.03	.05	.06	.07	.09	.12	.15	.16
	B.	932	1 244	1 602	2 187	2 751	3 655	4 655	5 981	7 752	8 528
France	A.	.05	.06	.06	.07	.08	.09	.11	.13	.15	.15
	B.	2 109	2 406	2 769	3 117	3 499	4 358	4 978	6 117	7 503	8 114
W. Germany	A.	.04	.05	.07	.08	.09	.11	.13	.15	.19	.21
	B.	1 753	2 393	3 301	3 985	4 732	5 994	7 047	8 802	11 249	12 456
Sweden	A.	.19	.23	.28	.31	.32	.35	.38	.43	.49	.51
	B.	1 316	1 615	1 994	2 220	2 312	2 637	2 904	3 387	3 935	4 111
Japan	A.	.01	.02	.03	.03	.04	.06	.08	.14	.12	.19
	B.	1 150	1 664	2 595	3 123	3 886	5 527	7 356	13 999	17 331	19 899

*1948
A. Number Per Capita
B. Number in Use (Thousands)
Source: "Communications: Telephones, Number in Use", *United Nations Statistical Yearbook, 1949-1970,* United Nations, New York, 1971.

hardware. Because much of this is rental revenue, and because the industry is in a state of rapid growth, rental figures are much lower than the sales value of the equipment put into service in a year.

In the field of scientific instruments, our high levels of expenditures on health and education have created markets which exceed what would be expected simply on the basis of our GNP. OECD, in its Report on *Gaps in Technology*[12], estimated the domestic market of some European countries for scientific instruments in 1965 as follows: Belgium $20.4 million, France $154.2 million, Italy $62.24 million, Japan $212.82 million, Sweden $50 million. In 1966 Canada *imported* $125.4 million worth of scientific instruments.

In summary, the Canadian market for the products of science-based industry, in comparison to that of other nations, appears to be: very much smaller than that of the U.S. (5 to 10% of it); slightly smaller than that of the larger West European countries and Japan (ranging from the same size to 50% smaller); and very much larger than that of the smaller countries of Europe.

It is often argued that one should not compare our domestic market with any one country in Europe, but rather with the "trading blocs" as a whole (EEC or EFTA). This argument is not valid on at least three counts. First, there are relatively few high-technology products in which any given country exports more than 25 per cent of its production to other countries within its trading group. Indeed, the data given earlier in Tables III.7 to III.13, as well as in Table IV.6, show that the total international trade in these products is very much less than the domestic consumption in most countries. The second point is that, when a country succeeds in selling large volumes of a product to the member nations within the group, it inevitably does well with that product on world markets generally. Finally, many of the trends which were described in the early chapters are based on longer-term patterns, and were discernable before the "trading bloc" argument had any validity at all.

OECD, in its study of the *Conditions for Success in Technological Innovation* (Paris 1971), considered quite specifically the effect of the size of the national market on the performance of member countries in technological innovation. They found that no correlation existed, and summarized their findings on this question as follows;

"Studies in the U.S.A. have suggested that the size and sophistication of the U.S. market has been a key factor in the innovative strength of U.S. industry. However, this explanation does not appear to hold for all Member countries. There are countries with very small national markets, but also with the technological and entrepreneurial capabilities enabling them to respond to demands for innovation on world markets. However, overcoming barriers to national markets has its costs, and can reduce the rewards and returns to successful innovators. In particular, the penetration of foreign government markets appears to have been particularly difficult, and to have had important effects on patterns of innovation performance in certain sectors."

[12]OECD, *Gaps in Technology: Scientific Instruments*, Paris, 1968.

Nevertheless, this study has found that there is a correlation, and a very strong one, between the number of large firms in a country and innovative performance. It was stressed by the authors, however, that while the presence of large firms appears to be necessary this does not imply that these large firms are themselves the principal innovators. On this point, the authors say that the empirical evidence suggests that large and small firms play roles that are "complementary, in that larger firms have tended to contribute most to innovation in areas requiring large-scale R & D, production or marketing resources, whilst smaller firms have tended to concentrate on the supply of specialised but sophisticated components and equipment – often with large firms as customers".

It seems only reasonable that, in the final analysis, what is of greatest significance with respect to markets is the *size of market that a well managed company can reasonably expect to gain.* For practical purposes, what this means for a Canadian manufacturing company is the total national market for the product concerned minus imports of that product, with the difference divided by the number of serious competitors.

Because our domestic market is inherently modest, though not hopelessly small, we must concentrate our energies in order to develop production units that are internationally competitive. This means not allowing large segments of that market to get eroded by imports; it means encouraging the development of as few strong production units as are consistent with consumer protection; it means developing proprietary native product and production technology which will give us a competitive edge in some products in which we choose to specialize.

Unfortunately, our policies have not succeeded in bringing these things about; on the contrary, they appear to have permitted the opposite to occur. Imports and fragmentation of production capability have made our already limited market intolerably small in terms of what any individual producer can reasonably expect to get; our product and production technology is copied from others and rarely improved upon, thus eliminating the possibility of any advantage from that side. For the most part, this has not been done by design but rather because of a failure to understand the nature of the forces that are at work. One must concede, however, that short-range political expediency may have contributed materially to this unhappy situation.

Market Size and the Subsidiary

Because such a large portion of our secondary manufacturing industry is carried out by the subsidiaries of multinational corporations, it is important to consider the special problems that small markets present to these firms. For subsidiaries, there is a factor that intervenes to make their situation entirely different from that of independents, and that factor is the existence of a free exchange of technology between the parent and itself. Almost without exception, subsidiaries of foreign-owned multinational companies stated that they have unrestricted access to the technology of the parent. Since most large U.S. companies and a substantial number of large corporations of other advanced countries have Canadian subsidiaries, this means that "Canadian industry" has access to many billions of dollars of R & D. This exceeds by a factor of perhaps 50 the total R & D done by Canadian industry.

The corollary to the subsidiary's access to the technology of the parent is the parent's access to the technology of the subsidiary. In terms of the volume and the intrinsic value of the available information, the subsidiary stands to receive more than it gives by an order of magnitude or more. For this, it will normally pay a fee which is but a very small fraction of the cost of producing the information. One might at first wonder why subsidiaries do not draw more benefit from this arrangement, which is so overwhelmingly in their favour, or how independent companies can manage to compete without equal benefits. The answer, as it affects the "miniature-replica" type of subsidiary[13], lies largely in the available market, economies of scale and learning curves.

A two-way free flow of information will quite naturally lead to both parent and subsidiary using basically the same product and production technology. In the first place, both will want to use the "best technology", which presumably will be the same for both. In addition, for reasons which will be discussed later, there are advantages for a subsidiary in using essentially the same technology as its parent. This use of the same technology has the effect of equalizing the technology aspects of the production costs; the *scale* aspects are then likely to become determining. Materials, labour and other costs will usually not be sufficiently in Canada's favour (if they are at all) to tilt the scales our way if there is a large disparity in the scale of operations. In addition, the product will in most cases have originated with the parent and, as a result, the manufacturing plants of the parent will be further on down their learning curves than the subsidiary. As it is "only good business to export from the country that has the lowest costs of production", the subsidiary is not likely to be permitted to build up its volume through the development of an export market; as a result of this, the "miniature-replica" type of subsidiary is likely to see itself as hopelessly constrained by the limitations of "Canada's small domestic market".

Imports

We often hear the statement that "Canada is a Trading Nation". To many, the expression conveys a sense of internationalism, of development and of industrial sophistication. However, when we examine the nature of our imports and exports, we find that we export mainly raw materials and resource-based products, while importing mostly manufactured goods, particularly those which have a high knowledge content. Our pride in being a trading nation must be tempered by the realization that we excel in the sale of those products that most developed countries want, on which they impose no tariffs, and which they use to make products for sales abroad, thus creating jobs for their citizens. On the other hand, we are the world's

[13]Arthur J. Cordell, *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy*, Science Council of Canada Special Study No. 22, Information Canada, Ottawa, 1971.

leading importer, on a per capita basis, of manufactured products (Table IV.8).

Table IV.8–Imports of Manufactured Goods, 1969 (Million U.S. Dollars f.o.b.)

	Total Manufactured Goods	Per Capita
Canada	9 780	463.75
EFTA	24 250	242.12
EEC	44 260	239.17
Australia, New Zealand	3 505	236.38
U.K.	8 300	149.46
U.S.	23 620	116.23
Japan	3 920	38.31
World	176 010	49.43

Sources:
–*United Nations Statistical Yearbook, 1948 to 1970,* United Nations, New York, 1971. Page 80.
–*The Monthly Bulletin of Statistics,* Vol. xxv, United Nations, New York, March 1971. Page xvii. (Total Manufactured Goods was the sum of Chemicals, Machinery and Other Manufactures).

It is these types of products that other countries most resist buying, and upon which they impose tariffs and very frequently other less obvious but equally effective trade barriers. One has only to recall Table III.6 to realize how overwhelmingly biased toward manufactured products are our imports, and how biased toward raw materials are our exports. Moreover, Tables III.7 to III.11 and Tables A.1 to A.7 (in the appendix) illustrate that the products most imported are often the most sophisticated and the most technology-dependent.

Even more significant than the absolute magnitude of imports are the trends of recent years. In almost all of the key sectors identified by OECD, the data for which are presented in Tables III.7 to III.11, the level of Canadian imports has risen and our trade balance has deteriorated between the time of the OECD Study and the time for which the latest information is available.

Many of the executives interviewed made allegations that governmental and quasi-governmental bodies in Canada are much more inclined to purchase from a foreign supplier than are their counterparts in other countries. While there seems to be considerable validity in these allegations, it is very difficult to establish this in a fully documented manner. Few countries will openly admit to having a purchasing policy that clearly discriminates in favour of domestic suppliers. Most will outwardly claim to have a policy of buying from the bidder who presents the optimum combination of price, quality and delivery, relying only on tariffs to protect native industry; but it is well known that in practice most governments, government agencies and agencies financed or closely regulated by governments (e.g., utility companies, schools) will strongly favour the domestic manufacturer. For example, it is observed that, even between countries that are members of a common trading group, there is little trade in products that are purchased mainly by governments, wherever the products are manufactured in each of the countries concerned. In this connection it is interesting to consider the information presented by the Canadian Electrical

Manufacturers Association to the Anti-dumping Tribunal's 1970 Hearing on Power Transformer Dumping in Canada. This information, which is reproduced in Table IV.9, shows that power transformers such as those used by power utility companies are sold almost entirely on home markets. Despite the existence of the EEC and EFTA, and despite the fact that many of the European countries included in the group do not have a well developed electrical manufacturing industry, only 5 to 10 per cent of sales, on average, were made in other OECD European Countries.[14] During the period in question Canada, with a well developed transformer industry and not belonging to a trading bloc, was buying up to 25 per cent of its requirements abroad[15], despite the fact that its industry was working at two-thirds to three-quarters capacity.[16]

Documented information of this type is very scarce, however, so that on this question one must rely on private observations and individual cases. These, although quite numerous, do not have statistical significance.

Some of these observations may nonetheless be worthy of mention. In the course of discussion with EEC staff personnel in Brussels, the point was made that one of the most serious impediments to the achievement of a true common market was the purchasing policies of member countries' governments and government-controlled agencies. Each country persisted in purchasing almost exclusively at home, thus making it virtually impossible to achieve any degree of rationalization in products that are by nature sold mainly to government-controlled agencies. In like manner, a senior vice-president of a large U.S.-based multinational company told us that in his experience Canada and the United States were the two countries whose publicly owned or controlled agencies were the most uninhibited insofar as purchasing abroad is concerned. In his words, "We [the U.S.] are big enough to allow ourselves the luxury of this kind of folly, but I don't see how it can make any sense for a country like Canada".

In a recent brief to the Tariff Board, the National Cash Register Company of Canada had these comments to make:

"As a result of its experiences in all of the foregoing cases, NCR has a strong awareness of the lack of policy co-ordination within the Federal Government. However, in none of the foregoing cases was it brought home so forcefully as it was in connection with the Federal Government's purchasing policy. NCR recently suffered a negative and costly experience in this regard when it bid on a Department of Supply and Services request for proposals to supply "Data Communications Terminal Equipment" for the Royal Canadian Mounted Police.

With its more than 70 offices in Canada available for servicing, NCR believed that on an overall purchase-and-service basis it was the lowest bidder. Furthermore, NCR proposed to undertake a maximum of assembly and production of the equipment in Canada. Yet, the award was made to a

[14]Canada, Anti-dumping Tribunal. Evidence presented at hearings, investigating charges of dumping of power transformers. CEMA Exhibit #17.

[15]*Ibid*, Exhibit #1

[16]*Ibid*, Exhibit #4

Table IV.9–Annual Deliveries of Power Transformers Above 500 KVA (0.5 MVA) to OECD Countries[a] by European and Japanese Manufacturers (Units: MVA 000)

	Actual					Est.	Projected			
	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
OECD Europe Mfrs. Deliveries to Home Markets:										
Austria	1.29	1.16	1.94	1.40	1.76	2.44	3.80	2.68	2.56	0.56
Belgium	1.06	2.01	2.89	2.24	1.17	0.73	0.11	3.19	1.43	2.14
France	7.82	8.15	7.62	9.45	10.41	8.09	12.19	12.80	7.45	10.35
Italy	8.55	4.57	5.04	7.86	11.65	6.68	14.10	14.05	14.48	14.80
Germany	16.28	15.66	12.46	12.17	14.59	14.61	13.18	10.14	19.76	22.37
Sweden	4.03	1.75	1.85	5.28	3.25	4.67	3.58	3.92	3.71	5.44
Switzerland	1.71	1.60	1.84	1.16	1.33	2.29	0.70	2.27	0.24	0.35
U.K.	37.46	33.95	37.61	38.69	35.55	32.25	33.50	33.50	23.80	18.30
Other Producers[b]	8.20	8.07	10.65	12.81	16.50	15.79	14.88	12.05	15.68	12.20
Totals	**86.41**	**76.93**	**81.80**	**91.07**	**96.20**	**87.55**	**96.04**	**94.60**	**89.11**	**86.51**
Deliveries to other OECD Europe Markets	8.21	8.21	5.08	5.57	9.29	11.43	5.78	7.15	10.55	13.04

[a]Excluding Canada and U.S.
[b]Denmark, Ireland, Netherlands, Norway, Portugal and Spain.

Sources:

–OECD, 18th to 22nd Surveys of Electric Power Equipment cover European years 1964-69. Japan Electric Power Survey Committee covers 1964-69. In OECD Europe figures, power transformers rated at less than 5 000 KVA for the years 1964 and 1965 and at less than 10 000 KVA for the years 1966 and following, and projections by General Electric Company, New York.

–Table Reproduced from Exhibit #17 of the Canadian Electrical Manufacturers Association brief to the Anti-Dumping Tribunal's 1970 Hearing on Power Transformer Dumping.

representative of a U.S. firm which maintains a small, single office in Canada and which proposed to supply equipment entirely designed and manufactured in the U.S."[17]

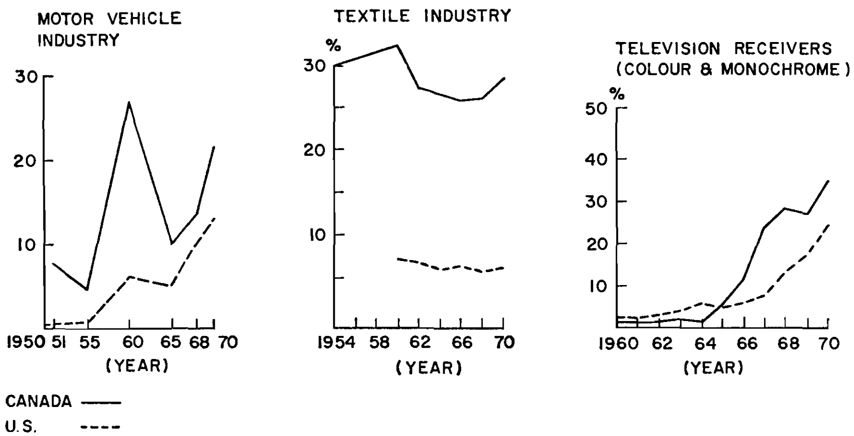
Many of us who have had the opportunity to visit government and university laboratories abroad have noticed the preponderance of domestic equipment that exists in the laboratories of industrially developed countries, in contrast to Canada, where equipment of Canadian design and fabrication is almost totally absent. In government laboratories in Japan, one is hard pressed to find any equipment at all that has been imported. Does this observation simply reflect the absence of a significant scientific industry in Canada – or is the absence of a scientific instrument industry a consequence of our purchasing policies?[18] Large quantities of equipment and supplies of foreign manufacture are also purchased by our hospitals, our publicly owned telephone companies, our publicly owned broadcasting company, our publicly owned airline and other agencies that are owned or controlled by the various levels of government or that depend heavily upon the public purse. On the whole, these agencies purchase in the manner that they consider will most advance their particular mission. Most do not consider that the support of Canadian industry is an important part of that mission. Many good arguments can be presented in favour of such a position, and it is, moreover, the stated position of comparable agencies in most other countries. Officially, the rules of the game in this matter of purchasing from other countries are quite uniform among the industrial countries; the differences occur in the integrity with which they are applied. Judging by the level of imports by our government agencies, we surely must merit the award of "International Boy Scout".

Governments, of course, are not alone in showing a great readiness to buy foreign-made products. Over the years, the Canadian consumer has shown less bias in favour of domestic products than his counterpart in Japan, Europe or the U.S. For example, whenever foreign-made products have made deep inroads into North American markets, it has almost invariably been the Canadian market that was penetrated first and deepest. Figure IV.3 shows the penetration of Canadian and U.S. markets by three typical consumer products (television sets, automobiles and textiles). In each case, the displacement of the domestic product occurred sooner, and to a greater degree, in Canada than in the U.S. Despite the proportionately more minor impact that these imports have had on markets in the U.S. than they have had on Canada's, the protective actions that have been taken by the United States in response to these growing imports have been more vigorous than ours. A possible reason for the Canadian consumer's "laissez-faire" attitude toward the origin of the product he buys is perhaps that there is so little that he can identify as "Canadian". It is often difficult to determine if, and to what extent, a product is manufactured in Canada. Very often, the clerk selling a television set, a refrigerator, an automatic washer, or some other item does not know whether or not it is of domestic

[17]Brief in response to Canada Tariff Board Notice R183, Reference No. 150, "Computers and Related Telecommunications".

[18]For quantitative evidence of the weakness of this industry in Canada see Table III.10.

Figure IV.3–Percentage that Imports Contribute to Total Domestic Market



Note: Since motor vehicles are a special case, imports from the U.S. have been excluded.
Sources:
–Canadian Textiles Institute, *Textiles: A Study of the Canadian Textile Industry*, Montreal, November 1971.
–Verbal Communication from Mr. Daniels, Chief Statistician, Canadian Textiles Institute, Montreal.
–Verbal Communication from D. Wilson and L. Clarke, Manufacturing and Primary Industries Section, Statistics Canada.
–U.S. Bureau of the Census, *Statistical Abstract of the United States: 1969*, Washington, 1970.
–U.S. Department of Commerce, *Survey of Current Business*, 52(2), February 1972.
–DBS: "Radio and Television Receiving Sets, Including Record Players", Catalogue No. 43-004; and "Importations par Marchandises", Catalogue No. 65-007.
–*Electronic Market Data Book, 1971; Industry Sales and Trends through 1970*, EIA, Washington, 1971.
–DBS, *Trade of Canada, Imports by Commodities*, Catalogue 65-007: 1951, 1955, 1960, 1965, 1968, 1970.
–U.S. Department of Commerce, Office of Business Economics, *Business Statistics*, 1971.
–*Canada Year Book, 1970-71*, Statistics Canada, Information Canada, Ottawa, 1970.

manufacture. It is doubtful whether there is another country in the world where this happens as frequently as in Canada. The fact that it is common for the clerk not to know is a good indication that the customer does not much care.

Industry's attitude toward importing is no better than that of governments or consumers; it may in fact be worse. While campaigning to incite government agencies and the general public to be more patriotic when purchasing, industry itself has been freely importing capital equipment, parts, materials and completely manufactured merchandise for resale. One has only to consider the high level of importation into Canada of those items which are purchased mainly by industry. In that category one must include electronic components (Table III.11 and A.7), machine tools (Table III.12), nickel aluminum fabricated materials (Tables A.1 and A.2), asbestos manufactured products (Table A.5), many of the sub-categories of chemical imports (Table A.6) and a multitude of other products for which data are not presented in this report. In many cases, the obstacle to getting a Canadian source for parts and materials is not that the Canadian material would cost more, or be of lower quality, or have a longer delivery time. It is rather that the product being manufactured was designed and first produced with parts and materials from a non-Canadian source. To change supplier can mean inconvenience, it can mean added costs, and it can mean greater risks. The new suppliers' product must be evaluated and the parts and materials specifications may have to be changed; those of the finished product itself may have to be somewhat modified. In addition, the assurance of satisfactory performance achieved through accumulated experience will be lost. The Canadian source must not only be competitive, but it must also show sufficient advantage to overcome this inertia barrier, which in many cases can be very substantial.

Not only do Canadian manufacturers import many of their components and materials from abroad, but they also import large numbers of finished products for resale in Canada. For example, Canadian producers of television receivers are themselves selling imported sets at a rate of nearly 100 000 per year.[19] This practice is also common for other products and other industries. Deluxe models, specialty items and, in general, products with limited sales volume can frequently be imported more cheaply than they can be made, particularly by subsidiaries of foreign-owned companies who can enjoy a privileged transfer price. Moreover, the amount of "manufacturing" that goes into some items – from business machines to pharmaceuticals – is often not much more than a formality.

It is normal for domestic industry to oppose the invasion of its markets by foreign products in every way that it can. Thus, we see in most countries strong industry lobbies which attempt to influence the politicians and the bureaucrats, and which take various concerted actions intended to influence the buying public. Canadian industry also does these things, but its actions are often tempered and muted by the ambivalent position of many manufacturers. The interests of the international corporation do not always coincide with the narrower interest of the Canadian subsidiary. For example, it is important to sell at a profit, on the Canadian market, a product manufactured by the corporation; that the product be made by the Canadian subsidiary may be considered desirable but it is not likely to be considered essential. Similarly, there are likely to be substantial advantages for the international corporation, and often for the subsidiary itself, in not impeding the flow of parts or materials.

Canadian managers of foreign-owned subsidiaries are not fundamentally less patriotic than the rest of us; they will often take and successfully defend positions which favour Canadian national interests above those of the global corporation, when such conflicts arise. It would be foolish to pretend, however, that as managers of subsidiaries of multi-

[19]EIA of Canada

national corporations they are subject to the same incentives and the same constraints as managers of independent corporations. These incentives and constraints cannot but be reflected in attitudes and decisions, regardless of the goodwill and integrity of the individuals concerned.

In this connection we have recently seen the Canadian Business Equipment Manufacturers Association appeal to the Tariff Board to have tariffs totally eliminated on almost all business machines and their parts. It is stated in the Association brief that 60 to 75 per cent of the cost of manufacturing these machines is for parts, and that "Canadian industry cannot or will not supply" these parts. While it is true that component manufacturers do not supply these parts, the reasons have more to do with the way in which these companies do their purchasing and approve their suppliers than with the component manufacturer's technical limitations. These companies cannot buy many of their parts from Canadian manufacturers because *only their own parent company is an approved vendor*; for many others, only the parent can approve a vendor. In addition to importing parts and subassemblies, these manufacturers import large quantities of equipment completely assembled.

It is also noteworthy that Canadian "manufacturers" of office and store machinery, which is the category under which most business equipment manufacturers are listed, have, on average, only about 25 per cent[20] of their work force employed in production. By contrast, manufacturers of electronic industrial and commercial products in the United States have 57 per cent of their employees indentified as plant workers, not including the engineers, administrators and clerical workers engaged in production activities. The sub-group of computer manufacturers in the United States, who have the lowest ratio of production workers to total employees, have 42 per cent of their workers employed as plant workers.[21] It is also noteworthy that, of a total Canadian "value-added" of $297 million reported by manufacturers of office and store machinery manufacturers in 1969, only $84 million came from manufacturing activities.[22] Clearly, the principal activity of these companies is not manufacturing, but importing, sales and servicing. One should not be surprised, therefore, to find them defending positions that are more in the interest of importers than of manufacturers. There are many managers of foreign-owned subsidiaries who have similarly divided interests.

A net effect of this will be that the "voice of Canadian industry" and its lobbies will be less unanimous, less militant and consequently less effective than would otherwise be the case. This may explain in part why, despite the difficulties which beset our secondary manufacturing industries, we seem to maintain fewer trade barriers than most countries. From an international viewpoint, the elimination of tariff and non-tariff barriers is certainly a good thing; but is Canada really big enough, or strong enough, to lead the world into freer trade by its good example?

[20]DBS, "Manufacturiers de Machines de bureau et de magazin", (C.T.1. 318). Catalogue No. 42-216.

[21]*Electronic Market Data Book 1971: Industry Sales and Trends through 1970*. Electronic Industries Association, Washington, 1971.

[22]DBS, Catalogue 42-216.

Foreign Technology Sourcing and Imports

As was pointed in Chapter I, technology can be transferred in a wide variety of forms. At one extreme, it may be transferred fully embodied in a product or a material; at the other, it may be transmitted as generalized concepts and data which may serve as a basis for the development and design of a product or process. In between these two extremes, it may be transferred at any of the levels of processing through which concepts and data must pass before they can be used by production workers on a factory floor. This final form of processing is usually an extensive series of instructions, specifications, engineering drawings and similar documents which describe in great detail the product, the process for making it and its component parts, the materials that must be used, the production machines that are required, etc. Technology in this highly processed form has more value-added, but a much narrower range of applicability, than it has in the form of more generalized concepts and data.

Because this is the form of greatest immediate value, technology generated by a parent for its own use will often be transferred between parent and subsidiary in this way. Because of extensive penetration by multinational corporations, Canada receives much of its technology in this form. The similarity in market conditions between the U.S. and Canada further favours this kind of transfer in cases where Canadian subsidiaries have U.S. parents.

Specifications and drawings transferred in this way may subsequently be modified to take into account the size of the Canadian market, the tastes of the Canadian consumer or the capabilities of the Canadian parts material suppliers. But to transform specifications and drawings requires engineering effort, costs money, involves risks and may have the disadvantage of resulting in a product different in some ways from that produced by the parent. The benefits gained from tailoring to Canadian conditions must thus be weighed against the costs and disadvantages of making the changes. The smaller the available market, the less likely it is that changes will be worthwhile.

Of particular interest with regard to imports is what is done in the case of parts and material specifications. If they are not transformed in any way, this can have severe repercussions for Canadian suppliers. The most severe situation occurs when the imported specifications describing the parts or materials to be used actually specify the suppliers by name. In this situation, the potential Canadian suppliers are frozen right out, and everything is imported until the specifications can be changed. More frequently, the specification for a material or part will not name a particular supplier but, because it was originally written "around" a particular supplier's product, it will favour him quite substantially. If the specification was generated outside the country, the part described by the specification will almost certainly be that of a foreign supplier, and the onus will be on the Canadian supplier to duplicate the characteristics of that product. This, of course, puts the independent Canadian supplier at a very severe disadvantage, for it is much more difficult to duplicate the characteristics of a product than it is to produce one of equivalent or even of superior quality.

Formal Product Approval

As products have become more complex, and as the need for reliability has increased, manufacturers of products having a large technological content have increasingly gone to a system of approving materials and parts through an elaborate and formally established procedure. This procedure often involves approval of the supplier's facilities themselves. As this formal approval of suppliers is quite complex, usually requiring expensive equipment as well as highly trained people, it is often done at one location only in the multinational corporation. Many subsidiaries do not have such facilities, and rely on headquarters or on one of the major parent plants for this service. The Canadian supplier, wishing to supply materials or parts under this system, faces some severe hurdles. The nature of these is probably best illustrated by the two following examples:

Example 1: Company XY is a subsidiary of a U.S. corporation which builds aircraft navigational equipment in Canada. This particular subsidiary has research and design facilities in Canada, and many of the products which it manufactures are the result of research and engineering done here. However, this firm manufactures a product in which reliability is important and, therefore, it requires formal approval for all parts used in its equipment. The Canadian subsidiary is not equipped to approve suppliers of materials and parts. Thus, in the design of new equipment in Canada, parts originating in the United States and approved by U.S. Head Office are used. Unless a new supplier is approved, these parts must also be used in production. As the cost of doing the testing required for approval is quite high (costing thousands of dollars), Head Office is reluctant to evaluate a new Canadian source unless the Canadian manufacturer is himself prepared to pay the cost with no guarantee of being approved. Head Office would perhaps consider approving a Canadian source which could supply to its main plants in the U.S. and other countries, but certainly not a Canadian source that has a mandate to sell in Canada only, or to a Canadian source whose parent facilities are already on the approved list. The final result is that company XY continues to import parts from Arizona, while a Canadian manufacturer, also a subsidiary of the U.S. firm, manufactures the same parts less than three miles away, and is prepared to sell it to Company XY at a lower laid-down cost than Arizona.

Example 2: As a result of the Canada-United States Auto Agreement, a large U.S. manufacturer of an automobile subassembly has located a plant in the Toronto area. This plant is responsible for manufacturing a very substantial portion of North American requirements for the subassembly in question. However, the Canadian operation involves only assembly, and all of the other functions, including engineering and quality assurance, remain in the United States. A Canadian supplier, knowing what parts go into this auto subassembly, attempts to sell to this plant. The Canadian supplier is told that his product is not approved and that he must submit samples for approval. The Canadian supplier complies and provides samples. One year and many enquiries later, the Canadian supplier is still not approved. The engineer ostensibly in charge of approvals for the Canadian automotive subassembly manufacturer is evasive when asked why approval is not forthcoming. After some digging, the Canadian parts supplier realizes that all approvals are granted by the quality assurance laboratory in the U.S. mid-west. (The Canadian engineer was reluctant to give this information, and thus reveal his limited authority.) The sales manager and the chief engineer of the Canadian supplier journey to Chicago to meet the man in charge of approvals. The meeting is cordial, and within an hour the Canadian supplier is approved to supply parts to a plant a few miles from home. This particular example has a happy ending; but how many cases are there in which the supplier never identifies the problem and thus never gets the business?

For these reasons, transferring technology from a foreign source in fully developed and detailed form will have the effect of favouring foreign suppliers of materials and parts. Moreover, the effect will be strongest for those materials and parts that have the greatest technology content. This is the reverse of what happens when the technology is developed and elaborated domestically. In that case, the natural advantage goes to the domestic supplier.

Some companies, recognizing this problem and wishing to be good corporate citizens, have undertaken by deliberate policy to seek out Canadian suppliers, to evaluate their products and to modifying their specifications where necessary (and possible) to accommodate these suppliers. Unfortunately, these efforts have not been as widespread nor as intense as we might wish.

A full evaluation of the extent to which the source of technology can affect the source of supply of materials and parts is not possible, as there are no data directly relating these two parameters. The best that can be done is to examine the purchasing patterns of foreign-owned subsidiaries, for which some limited data are available, and to look for correlations between the country in which the company is controlled and the level of import of merchandise from that country. As Table IV.10 clearly shows, the country of control has a profound effect on where a subsidiary will purchase its supplies. This cannot, of course, be considered as due entirely to the location of the source of the subsidiary's technology. Because the natural relationship of parent to subsidiary would tend to produce a high level of trade between the two, and since the parent's main production facilities are likely to be in the country of control, such a correlation could be expected in any event. However, even when one separates the purchases from parents and affiliates from those from non-related companies and then looks at how these break down by country of control, one finds that the country where control is held (or where technology is sourced) still influences the source of purchases. This can be seen by considering Tables IV.11 and IV.12.

We see from Table IV.11 that, even when dealing with unrelated companies, the imports of subsidiaries are biased quite strongly in favour of the country where the company is controlled. The most plausible explanation for this effect is the influence of technology source. For example,

Table IV.10–Comparative Import Patterns of U.S.-Controlled and Other Foreign-Controlled Subsidiaries in 1967

Source of Imports	Reporting Corporation Controlled in:			
	U.S.		Other Foreign Countries	
	Value, $ Millions	%	Value, $ Millions	%
Imports from U.S.	3 124	87	178	38
Imports from Other Countries	467	13	294	62
Total Imports from All Countries	**3 591**	**100**	**472**	**100**

Source: Canada, Department of Industry, Trade and Commerce, *Foreign-owned Subsidiaries in Canada, 1964-1967*, Queen's Printer, Ottawa, 1970.

Table IV.11–Imports from Affiliates by U.S.-Controlled and by Other Foreign-Controlled Corporations

	Reporting Corporation Controlled in:			
	U.S.		Other Foreign Countries	
	Value, $ Millions	%	Value, $ Millions	%
Imports from Parent or Affiliates in U.S.	2 253	87	41	15
Imports from Parent or Affiliates in Other Countries	332	13	228	85
Total Imports from Affiliates	**2 585**	**100**	**269**	**100**

Source: Canada, Department of Industry, Trade and Commerce, *Foreign-owned Subsidiaries in Canada, 1964-67*, Queen's Printer, Ottawa, 1970.

Table IV.12–Imports from Unrelated Companies by U.S.-Controlled and by Other Foreign-Controlled Corporations

	Reporting Corporations Controlled in:			
	U.S.		Other Foreign Countries	
	Value, $ Millions	%	Value, $ Millions	%
Imports from U.S. Corporations	871	87	137	67
Imports from Other Foreign Corporations	135	13	66	33
Total Imports from Non-Affiliated Corporations	**1 006**	**100**	**203**	**100**

Source: Canada, Department of Industry, Trade and Commerce, *Foreign-Owned Subsidiaries in Canada, 1964-67*, Queen's Printer, Ottawa, 1970.

a subsidiary whose parent is based in a country other than the U.S. (most non-U.S. subsidiaries have U.K. or West European parents) is almost three times more likely to purchase from a country other than the U.S. than is a corporation whose head office is in the United States. These data, moreover, cover corporations involved in a variety of businesses, from resource development to wholesale trade. In some of these businesses (for example, food and beverages and petroleum refining), there is little reason to expect that a company would buy preferentially in the country of control, except where dealings with parents or affiliates are concerned. On the contrary, since many of its needs from that country would be supplied by a parent or affiliate, one might expect that in the remainder of its purchases other countries would be favoured. It is probable, therefore, that if the manufacturing sector could be isolated, the correlation would be even higher. Again it is not possible to do this in a systematic way, as the data that are available by industry sector are not broken down by country of control. It is of interest, however, to consider the case of the transportation equipment industry, for this is an industry in which: a) parts and materials are purchased to well defined specifications and drawings; b) the technology is almost entirely generated outside of Canada[23]; c) the control of subsidiaries in this industry is mostly in one country (the United States).

Table IV.13–Imports in the Transportation Equipment Industries

	1964		1967	
	Value, $ Millions	%	Value, $ Millions	%
Imports from Parent & Affiliates				
In the U.S.	424	59	1 348	69
In Other Foreign Countries	38	5	49	2
Total from All Parents & Affiliates	**462**	**65**	**1 397**	**71**
Imports from Other Corporations				
In the U.S.	238	33	554	28
In Other Foreign Countries	15	2	15	0.8
Total from Unrelated Corporations	**253**	**35**	**569**	**29**
Total of All Imports	715	100	1 966	100

Source: Canada, Department of Industry, Trade and Commerce, *Foreign-Owned Subsidiaries in Canada, 1964-67,* Queen's Printer, Ottawa, 1970.

It is quite obvious from the data in Table IV.13 that in this industry the source of imports correlates well with the country of control, and consequently with the country of technology sourcing. This holds equally well with purchases made from companies that are not related to the subsidiaries in question, as witnessed by Table IV.13. Although more pronounced in 1967, the phenomenon was also evident in 1964, before the Auto Pact had had any special effect on the structure of the auto industry (the biggest constituant of this group). The capital equipment imports of this industry are also very strongly biased in favour of the United States. In the four years from 1964 to 1967 inclusive, this industry imported $248 millions' worth of capital equipment, 96 per cent of which was purchased in the United States and most of which (72% of U.S. purchases) was from companies not affiliated with the purchasers. The 4 per cent that was purchased in the other parts of the world was purchased mostly in the first year (i.e., 1964). In the three years that followed the Auto Pact, less than 2 per cent of capital equipment imports were from countries outside of the United States.

That the origin of the technology should influence the source from which equipment, supplies and materials are purchased should come as no surprise; many companies which make and sell components and parts, including successful and sophisticated companies like Philips, are known to maintain teams of engineers solely for the purpose of providing free design service for potential customers. The service is provided with "no strings attached", on the premise that the mere use of the designs, in whole

[23]Of the inventions in this industry group granted in Canada in the three years 1957, 1960 and 1963 (1790 in all), only 1.6% are owned in Canada, 84% are owned in the United States and 14.4% are owned in other foreign countries. O. J. Firestone, *Economic Implications of Patents,* Social Science Series No. 1, University of Ottawa, Ottawa, 1971.

or in part, will bias purchasing sufficiently to more than pay for the cost of the service.

Peter Drucker has stated: "There is no better and more effective way to create a market for one's own goods, and with them for one's own labour force, than through the sale of technology. Every penny of patent or licence income from a foreign country creates a market for up to a dollar's worth of goods from the country in which the new technology originated." We would argue that there is a better way "to create a market for one's own goods", and that that better way is by transferring the technology through direct foreign investment rather than through licensing.

This appears to be the most plausible explanation for the apparently peculiar situation which we find in Canada, whereby we are heavy importers of many products based directly on our natural resources. We refer here to Tables A.1, A.2, A.4 and A.5, which show that, while we are the world's leading exporter of nickel, aluminum and asbestos, and one of the leaders in platinum, we import more of the fabricated forms of these minerals than we export. It also explains the virtual absence of a machine tool industry and the overall weakness of our capital goods industries.

There is no doubt that Canada has paid, and is continuing to pay, a very high price for the technology it has received from abroad at what may superficially appear to be bargain prices.

Access to Foreign Markets

Although industries are seldom built primarily on export markets, foreign markets can be a very important supplement to a manufacturer's domestic market. This is particularly important in countries which, like Canada, have an intrinsically small home market.

If we assume, as is generally done, that exports are the outgrowth of production initiated for domestic consumption, then it would seem that because of market similarities the U.S. would be our primary export market area for manufactured goods. It also has the advantages of proximity and of being the world's largest and most sophisticated.

Most Canadian businessmen interviewed considered the American market to be one that was relatively unobstructed by non-tariff barriers for Canadian high-technology products. It is, of course, one of the most fiercely competitive in the world, but most believed that there is room in it for the manufacturer who can compete in price and quality, or again for those who have something unique to offer. The general impression was that in general Americans will not discriminate against a Canadian source merely because he is not manufacturing in the United States. There are of course many exceptions to this general rule. The principal ones occur in government organizations, at various levels, as well as in private utility companies that depend upon the government sector for the establishment of their rates. We also encountered some Canadian executives who felt they had lost U.S. export contracts because of political pressures that were brought to bear upon their American customers. Such allegations are impossible to prove or to disprove, and thus their significance, if any, cannot be evaluated. Overall, it would seem that resistance to imports from

Canada (and no doubt from other countries as well) arises almost entirely from the political and the public service sectors; even this resistance was not thought, at the time of the interviews in late 1970 and early 1971, to be as strong as what is encountered in Western Europe and Japan. The recent protective measures taken by the United States may have altered that situation.

Some Canadian manufacturers of high-technology products have expressed the view that the policy of buying domestically is so firm in the government and government-controlled agencies of some European countries that it is futile even to submit a bid. Because of distances and differences in social customs and standards, the markets of Europe and Japan are difficult and expensive to penetrate and to service. As far as could be discerned from the interviews, Canadian high-technology industry has made no significant penetration in these markets, except in a few very specialized products such as flight simulators.

As we saw in Chapter III, Canadian high-technology exports are very much lower than our imports in the same categories. The most frequently given reason for our apparent inability to export more was that costs in Canada are such that we cannot produce competitively. Since about two-thirds of Canadian high-technology industry is foreign-owned, and since in the great majority of cases the products manufactured by the Canadian subsidiary are also produced by the parent, most of the companies concerned were in the position of having to compare themselves with a parent who had access to the same technology and whose production level was greater than their own by a factor of ten. They quite obviously could not export into the parent's market, for economic reasons, even if permission had been granted. Third markets will be considered usually only if the Canadian plant has had the lowest costs within the corporation, an unlikely prospect in the light of the probable scale of operation in Canada. The condition that must be met under normal circumstances in order to decide if one should export is simply "is it profitable?". For most products, in most subsidiaries, the condition that must be met is the much harder one, "is the Canadian plant the *most* profitable one from which to export?".

This does not cover all situations, for there are many semi-autonomous subsidiaries which have developed one or more specialized products of their own and thus been granted an international product mandate by their parent. In most such cases, the product(s) for which they have such a mandate represents a small portion of their total business; but in a few cases it is an important aspect of the subsidiary's production. In this category we find the PT6 engine of United Aircraft, the STOL aircraft of DeHavilland, the mining and geophysical equipment of CIL, products of CGE's Dominion Engineering Division, and a limited number of others.

These international product mandates have been particularly successful where Canada has a clear comparative advantage because of our resources or because of the peculiarities of our market. Another condition that has favoured their development has been one where the parent has been prevented from entering a field in the United States because of antitrust regulations. In some cases multinational corporations have agreed to give their Canadian subsidiaries an international product mandate in association with (or in return for) cash grants given them through one of the incentive or regional development programs of the Canadian Federal Government. Some of these grants have amounted to tens of millions of dollars.

In the case where a subsidiary is allowed to have an exclusive mandate for a product, the international marketing network of the parent can be a very strong asset in helping it to gain export sales.

For the "rationalized subsidiaries", the problem of exports is entirely different. The reason for their existence in Canada is not primarily to serve the Canadian market, but rather to render imports into Canada more acceptable because they are at least partially counterbalanced by exports. These plants will often export up to 80 per cent of their production, and this will usually be sold almost entirely to the parent organization. The problem of penetrating foreign markets does not exist in the normal sense for this type of Canadian subsidiary; the level of exports from Canada will depend upon corporate decisions based upon production costs in Canada relative to those in other countries, and upon the degree to which it is perceived necessary to balance the corporation's exports from Canada with its imports into Canada. Although such firms may do R & D in Canada, their export performance will be virtually independent of Canadian-generated technology. The laboratory will normally relate directly to corporate R & D, and its incentives will come from prospects of increasing the profits and growth of the global corporation rather than that of the Canadian subsidiary.

The Canadian Image

As was stated at the beginning of Chapter III, the Canadian image abroad is not that of an advanced technological nation. This is especially true in countries of Western Europe and Japan, where the names of companies recognized as Canadian are almost entirely in the resource and resource-based industries. The names of Alcan, Inco, MacMillan-Bloedel, Noranda and Seagrams are associated with Canada but, not surprisingly, Du Pont, General Motors, IBM, Merck and RCA are not. On several occasions during our visit in Europe we were asked why we would want to get into high-technology industry rather than stick to the things we could do well, such as mining, lumbering, growing wheat and making whiskey. This image, and the natural preference for dealing with head office, no doubt greatly reduces the frequency with which clients will spontaneously seek out Canadian sources. To what extent it can undermine confidence when proper contacts are established is more difficult to assess. It seems reasonable to assume that for highly sophisticated equipment representing large investments, where the buyer must place considerable faith in the supplier, it may be a significant factor. Perhaps with a better image we could have sold more Candu Reactors.

Exports to developing countries are very much more dependent on the availability of low-cost financing (without strings) than on an image of technological excellence. Most industrial nations, conscious of the importance of an early penetration of these markets, have made such low-cost financing available. Through the Export Development Corporation Canada is doing as well as most countries in this regard. Most executives with whom we spoke appeared satisfied that the Canadian Export Development Corporation was doing an excellent job with a minimum of red tape.

Cashing in on a Major Breakthrough

Although usually not the main motivation for initiating R & D, the possibility of making a major breakthrough that could transform the company remains a major incentive for innovation. For many companies in Canada, this incentive is very much reduced, or does not exist at all.

The return that is realized from a major breakthrough will depend very strongly upon how quickly and how skillfully it is developed, engineered and marketed. For a number of reasons, the Canadian environment is not ideal for carrying a product through these crucial early periods of its life. The best market in which to introduce a major new product is usually the most sophisticated and the largest, and on both counts the U.S. or the European markets offer distinct advantages. Moreover, the weaker industrial infrastructure in Canada can make slower and more painful the development and engineering programs. For these reasons, and also because the largest, the most experienced and generally the most competent teams of engineering and marketing people in multinational corporations are usually found in the headquarters country, it is unlikely that a Canadian subsidiary would be allowed to carry through a highly promising development. Few companies would risk losing millions of dollars for the emotional reason of letting the Canadian subsidiary carry its invention through to fruition. One executive at Head Office in the United States stated quite frankly in discussion with us that any major breakthrough by the Canadian subsidiary, if it occurred, would probably be brought back to the United States for development and initial production.

Companies may do R & D in order to satisfy the politicians and bureaucrats that they are doing their best to be progressive and to be good corporate citizens; they may do research in response to cajoling, to threats or to hand-outs from governments; or they may do research to impress the general public. But unless there is real incentive to develop a new product or a new process, the research they do will not lead to innovation. Canadian industry, because of its structure, has been stripped of that incentive, and no amount of force-feeding of research will give the healthy vigorous activity that is needed to build a technologically capable secondary manufacturing industry.

V. The Ability to Innovate

The Many Skills Required for Success in Innovation

While the existence of incentive is a necessary condition for innovation and success in technology-based industry, it is by no means the only condition. More basic even than incentive is the underlying technology base which provides the capability for action. It is not possible to innovate without possessing "technological capability" in the area concerned. Keith Pavitt has described technological capability as "the ability to solve scientific and technological problems and to follow, assess and exploit scientific and technological developments. To an increasing extent 'technological capability' is the basis of power in the advanced industrialized countries – whether in terms of industrial competitiveness, defence, communications or prestige. In some ways, it bears the same relationship to the advanced country today as a maritime power base to the U.K. in the past".[1]

In order to possess technological capability, it is essential that a sound technology base exist, not only within a given company, but also, for reasons that will be discussed later in this chapter, within the environment in which the company operates. In Canada many companies lack technological depth despite the fact that technologically sophisticated products issue from their production lines. This fundamental weakness affects the environment for innovation and technological progress, thus reducing the effectiveness of those companies that do have some depth.

Successful product innovation most often begins in an industrial research laboratory where an apparently novel and promising idea is selected for preliminary development and first evaluation. Only a very small percentage of what their authors consider to be "novel and promising ideas" are so selected and, of the ones which are selected, most will fail the first evaluation and the project will be dropped at that point. The few that pass will usually be carried on to the point of advanced development, where a thorough marketing and technological assessment will be made. Those projects that pass the evaluations at this more advanced stage, and here the proportion will be larger, will go on to be engineered for production. Normally, this will involve designing and engineering the product itself, elaborating in detail the production procedures, designing and/or selecting the production equipment, and designing, laying out and building the plant. In addition it will be necessary to find suitable suppliers and to evaluate them and their products, to establish an appropriate marketing strategy, to raise the needed capital etc. Each of these activities requires special knowledge and skills, and failure in any one of them will almost certainly result in failure of the project.

On occasion, a brilliant and highly motivated individual, with the help of a few friends, will carry a product through each of these phases and successfully innovate. But these are rare exceptions, as the skills required are almost impossible to combine in a few people. Most companies which consider innovation to be part of their business will maintain teams that are

[1]Keith Pavitt, *The Multinational Firm and the Transfer of Technology*, Second Draft prepared for a Conference on the Multinational Enterprise, University of Reading, Berkshire, May 1970.

skilled in each of these functions. The combination of these teams of experts is what constitutes a company's "technological capability". The size of the team required for each of these functions can vary considerably, depending upon the type of industry; but, in general, adding a research laboratory to an existing production facility and sales office will not give a company the ability to innovate. Failure to recognize this fact has led to considerable disillusionment, and unproductive expenditures, on the part of many companies and the government departments that have supported them.

Moreover, in order to be effective, these mechanisms for innovation must be constantly exercised; if they do not have the need or the opportunity to function under conditions that tax their skills and energies, they do not develop the capacity for top performance.

We have seen in Chapter III that Canadian industry does relatively little research despite persistent efforts on the part of the Canadian Government to stimulate it. Weak as this first step in the innovation chain may be in Canada, we have gained the clear impression during the course of our interviews that it is relatively stronger than the mechanisms for performing the other essential steps in the innovative process. The incentives for research offered by Ottawa have not been without some effect; research laboratories exist today that would otherwise not have existed. This is much less true of capabilities for design, engineering and marketing, which have not been as generously supported. In addition, the possession of a research laboratory has been regarded by citizens and bureaucrats alike as a tangible demonstration of "good corporate citizenship"; many subsidiaries, mindful of their images, have moved to establish research laboratories even though they did not possess, or plan to establish, the means for translating the R & D results into products or processes in Canada. Several of these were identified in the course of interviews. The output from these R & D laboratories is of course not lost to the corporation, as it can be channelled into the engineering and design facilities in the parent company or to a subsidiary that has design capability. These research laboratories, while being of benefit to Canada in the salaries and general economic activity which they support, do not have the same significance to innovation in Canada as have laboratories accompanied by capabilities for design, engineering, evaluation, control and marketing. Likewise, they contribute little to the technology base of Canada in the operative sense, as they cannot interact in a meaningful manner with the mainstream of Canadian industry without these other services. Their interaction with other industries will rather be through the parent and, thus, with the mainstream of industry in the parent country.

Thus, although the level of research in Canadian industry is relatively low, the amount of research which has innovative potential and which contributes meaningfully to our technological capability is lower still. Paralleling this low level of activity in research and development is the low level of activity in engineering, design and some aspects of the marketing function. In a large number of companies they are not needed, or are needed only in a limited way, because the technology is available from a parent in fully developed form.

The Knowledge Component

In this age of technology, a substantial portion of the value of manufactured products is derived from the intellectual "labour" that goes into the research, engineering, design, quality assurance, management and similar activities which underlie not only the product itself but each of its component parts. In some products, this represents only a very small portion of the total value of the item, while in some science-intensive industries the costs of these knowledge inputs can be a very substantial portion of total costs. A part of this "knowledge component" must be added simultaneously with the labour and material inputs; for example, much of quality control, of engineering supervision and of the lower-level management must be done at the time and at the site of manufacturing. Other activities, however, may be performed quite independently and in separate locations. These rather less tangible inputs to a product may be transferred as required, in the form of data, instructions, specifications, engineering drawings, plant layouts, marketing strategies, etc. If they can be transferred from place to place, they can also be imported and exported, and because of their rather intangible nature it is easy for them to avoid duties and tariffs.

One of the important trends of recent years is that the volume of goods with a high technology content is expanding much more rapidly than the volume of goods whose value is derived mainly from materials and labour operations. In the home, there has been a more rapid growth in the volume of goods such as telephones, stereos, colour television sets and cameras than there has been in linen, furniture, utensils and similar goods. Likewise, in the office the rate of growth in the volume of computers, dictaphones and photocopiers has been more rapid than that of paper or filing cabinets. This trend is likely to continue in the future. Similarly, within any given class of products there is a continuing shift toward increasing the value of the knowledge component of the product relative to its labour component. This comes about for two reasons. There is, first of all, a rising level of sophistication involved in the research, development, engineering, design, control and the many other functions which depend mainly on intellectual activities. Secondly, the advent of automation, and its continuing penetration of manufacturing activities, is greatly reducing the labour content of goods. In view of these trends, it is important that we keep pace in the development of those industries that are knowledge-intensive. *What is more important is that we produce our share of the "knowledge component" of those goods.* The first point (i.e., our rate of development in knowledge-intensive sectors) was discussed earlier in this report and the point was made that our progress was not satisfactory. Rather extensive data were presented on this question in Chapter III, Tables III.7 to III.16.

These data, disheartening as they might be, do not fully reflect the seriousness of the situation. Indeed, a large proportion of those manufactured products which we do export have a "knowledge content" which was previously imported. This is well illustrated by the auto industry. Automobiles are by far our largest manufactured export item, and our trade in this product has had the effect of reducing our negative trade balance in manufactured goods in recent years. However, the present structure of that industry is such that knowledge-dependent activities are reduced to an extremely low level in Canada; in some sectors (e.g., research, development, design and engineering) they are, for all practical purposes, nonexistent. In many parts of the industry, even approval of parts, purchasing and similar activities are centralized outside of Canada. Thus, while we export automobiles, the Canadian "value added" is of a form characteristic of an industry of much less sophistication. Much the same holds true for a very large portion of the products that we manufacture for our own consumption. Since this knowledge component can cross borders duty-free and unmonitored and, moreover, since it is undiminished by sharing, it can be transferred at almost any price the principals agree upon. Within the same company, this makes for great flexibility in transferring this vital component of any high-technology product across borders. In effect, technology is an extremely easy commodity to "dump", and this is in fact what frequently occurs.

Intuitively, one might expect that technology transferred below its market value (or "dumped") would result in lower costs and, thus, in lower prices for products sold in Canada. There is no evidence that this is the case. Companies that have access to low-cost technology, mostly subsidiaries who have parents manufacturing the same product, do not sell for less than those which do not have such access. Moreover, selling prices in Canada are not particularly low in those products for which the technology is imported; if they were low, our balance of trade in these items would be better than it is at present. Indications are rather that this potential advantage is used to fragment our markets by making possible the entry of an excessive number of suppliers. Any potential benefits are lost in the operation of a multitude of small, inefficient and truncated plants. These points will be discussed in detail later in this Chapter and so require no further elaboration at this point.

The Information Pipeline

The fact that we receive most of our technology from other countries is not in itself a bad thing. All nations except the most powerful are in this position, and some do very well indeed by it. Japan, in particular, stands out as a country that has achieved technological excellence in many areas largely on the basis of imported technology. There is, however, a very fundamental difference in the manner in which Canada and Japan have gained access to foreign technology. Japan has gained access almost exclusively through licensing, while Canada has gained access through direct foreign investment.

One of the features of importing technology through direct foreign investment is that it is supplied on a continuous basis through an open "information pipeline". Its supply is assured over time and it can be modified at the input to suit the needs of the recipient. Thus, it can be supplied completely processed and ready for use by the workman on the production floor. The recipient need not understand it in any depth, for answers to his problems are as near as the telephone.

Another feature of technology obtained through direct foreign investment is that the recipient need not be concerned with continuously updating it, for new technology will be provided as it is needed. This can have very significant advantages for a small manufacturer. He can dispense with the high overheads he would otherwise need to sustain his technology and, while he knows that he can never become a leader, he also knows he cannot be left too far behind.

There are some significant disadvantages as well. His technology, and thus his product, will not be ideally suited to the needs of the market or to its size. As a result, he may have to manufacture too many varieties of a product (e.g., 300 varieties of mufflers) or sell products whose performance is less than ideal (e.g., automobile door locks that freeze in Canadian winters); he may also find that he is buying production equipment with more capacity than he will ever use, or that he is importing his parts and materials at higher costs because what is available locally does not conform to the requirements of his technology.

Innovation and the Technological Environment

In the complex world in which technology-based industry must operate, few companies can function independently of their environment. The scientist or engineer who is employed in industry cannot hope to possess more than a small fraction of the information needed to develop a new product or a new process in his area of responsibility. To be successful, he will have to know how to exploit outside sources for the additional information that he needs. Studies have shown that key transfers of knowledge in innovation have most frequently come directly from personal contacts with people, rather than through print.[2] The successful scientist or engineer engaged in innovation in industry will usually develop an intimate group of colleagues with expertise in areas adjacent to and partly overlapping his own, with whom he can discuss, draw inspiration and get advice. Some of these colleagues will be from within his own company, but many will be from without. Some of them will be scientists and engineers who hold positions roughly corresponding to his and who are employed by companies who are customers, suppliers and at times even competitors of his own. Others may be employed in government agencies or universities. This "outer circle" of professional colleagues that the innovator in industry has is analogous to the "invisible college" that de Sola Price has described in the world of basic science, except that the "circle" involved in innovation is likely to encompass a wider range of expertise and interests than does the "college" of basic science.

For example, an engineering development group in a company making transistors cannot function effectively, if at all, unless at least one of its members has intimate contacts with development engineers employed by the manufacturers of sophisticated electronic equipment who use transistors. It is also vital that members of the group have contacts with their

[2]U.S. National Science Foundation, *Successful Industrial Innovation*, NSF 69-17, 1969.

counterparts in companies which are competent manufacturers of silicon and of the other materials and parts used in the manufacture of transistors. In addition, they will need to know the key people in the pertinent government laboratories and standards agencies. Also important are the designers of the advanced processing and measuring equipment used in this industry. Knowing a certain number of university professors who are experts in solid state physics and in other relevant disciplines will also be a great asset. Many such circles are formed, each having a somewhat different composition; the circles intertwine, giving rise to a network that constitutes the basis of a nation's technological capability. Unless a company can effectively tie into this network, its ability to progress technologically will be strongly impeded. Successful coupling with the leaders in this network is not always easy, often depending upon personal relationships that rest upon mutual recognition of a high degree of competence. This can take many years to develop.

The Importance of the End-Product Manufacturer

For parts, components, material and industrial equipment manufacturers, it is especially important to develop very close relationships with the leading end-product manufacturers because, without the "demand-pull" that they provide, and without a "definition of need" to guide development, meaningful innovation is virtually impossible. Developing this kind of relationship can present a difficult problem for a small Canadian company, and if it must deal with a headquarters outside of Canada the problem can become monumental.

In most cases those responsible for developing or engineering a new product will, many mouths and sometimes years before the product is due for release, expose their anticipated needs to some "trustworthy friends" who are responsible for providing the needed technology in the supplier companies. The end-product manufacturers will do this to determine what they can reasonably expect from their suppliers from a technological point of view and to ensure that their parts and materials requirements can be satisfied when the time comes to go into production.

For suppliers this kind of information is vital, for it allows them to orient their development programs along meaningful lines. It is particularly valuable if the end-product manufacturer concerned is a leader in his field, and if he is in a technologically advanced area, because the parts and materials that he will be requiring next year will be demanded by others two and three years from now. The suppliers who are made privy to the needs of leading manufacturers will quite naturally have a tremendous advantage over those that are not. For this reason, it is important to have sophisticated end-product manufacturers in a country, and it is especially important that they do their development and engineering here.

When the technology is generated in another country, the suppliers who have that advantage are the suppliers of the country sourcing the technology and, when that technology is subsequently transferred to a host country, the advantage of the company which had advance notice will be transferred to its subsidiary. In this way, subsidiaries having parents in the country where the technology was generated will have a very marked advantage over indigenous companies and over subsidiaries with parents in other countries.

An example of how this works in practice may be found in the automotive industry. Prior to the Auto Pact, General Motors' "Canadian" automobiles were not built entirely to U.S.-generated specifications; one area in which their Canadian autos were different was in the paint. The paint which was used at the time was developed by CIL's paint research and development team in Toronto, in collaboration with General Motors. However, as a result of the Auto Pact, specifications were standardized for all of North America, and U.S.-generated specifications for paint were applied in Canada. CIL could no longer supply, and was displaced by the subsidiaries of the suppliers in the U.S. Its paint development team became superfluously large and had to be cut.

The reduction in the size of R & D activity in Canada did more than affect CIL's capability merely as it applies to the auto industry; it affected its capability in paints generally. The developments carried out for the auto industry quite naturally spill over into other areas and reinforce total activities.

We must also consider that the paint manufacturers play the same role toward the suppliers of the paint industry that the auto industry plays toward the paint manufacturers. The "lost opportunities" are thus transmitted down the line, and the suppliers of pigments and other materials used in paints will have less opportunity for the interactions which they require in order to keep abreast of the advancing technology. When these effects come from too many directions, the opportunities for innovation are reduced below the critical level and it becomes more advantageous to opt for an arrangement that permits the technology to be obtained, through licensing or direct foreign investment, from the country that originally sourced the technology for the paint. Again, it will be the subsidiary of the pigment supplier from the country sourcing the technology which will be favoured and, in the long run, get the business.

The final outcome of such a situation is quite clear. Industries in which the end-product companies source their technology outside of the country will become entirely dominated by suppliers from the country sourcing the technology, and research, development and engineering activity in that industry will completely cease. The automotive industry in Canada closely approximates the model of an industry where the end-product technology is entirely sourced outside of Canada. The results are as expected: the industry has become 95 per cent foreign-owned (almost entirely from the U.S.).

The auto industry is, of course, not a closed system. It interacts with other industries in literally thousands of places: in paints, in electronic components for radios, in plastics, in rubber, in ceramics, in steel and metal alloys, in rectifiers for alternators, etc. In all of these areas there are "lost opportunities" for innovation because there is no one to innovate for, or with. Moreover, the auto industry is not the only industry in which end-product manufacturers import technology; many companies in other industries do likewise, and the effects are the same, though perhaps less obvious. These effects are cumulative and, together, they create an environment which is hostile to innovation and technological progress.

The absence of any manufacturing of etched and formed aluminum foil in Canada is another illustration of how foreign technology sourcing has profound repercussions on products far down the supply chain from the original product whose technology was imported. This material, which is used in the manufacture of aluminum electrolytic capacitors, is imported into Canada from the United States, France and Italy. To produce it, and to thus upgrade the value of the aluminum from about 30¢ to up to $5 per pound, requires pure aluminum, electrical energy and technology. Labour requirements are low and capital requirements quite moderate. Aluminum, electrical energy and technology would seem to be things that Canada can provide; moreover, in the 1950s and the early 1960s, when most present suppliers became established, Canada was one of the world's largest consumers of this material. The first high-volume users of the capacitors that employed large quantities of this material were the telephone industry and the television set manufacturers. In both of these areas, Canada achieved a relatively high rate of production at an early date – which explains our relatively large market in the 1950s. The reason we are importing this high-value foil today, rather than exporting it, lies in "imported technology".

Northern Electric, who made most of Canada's telephone equipment, depended in the 1950s almost exclusively on Western Electric (U.S.) designs. Quite naturally, Western Electric equipment was designed to accomodate components of U.S. manufacture. The specifications covering the electrolytic capacitors used in this equipment described items that were available from two U.S. companies (Sprague and P.R. Mallory), and they showed these two companies as approved suppliers. In turn, the design specifications for both the Mallory and the Sprague capacitors, quite naturally again, called for a foil made in the U.S. Initially, the capacitors were imported whole from the U.S. Later, as the volume rose to substantial levels, both Mallory and Sprague began to assemble in Canada, but always to their original designs, which continued to be called for by Northern Electric. To have used a different source of foil for the capacitors would have required that they be redesigned, and it may have even required some minor design modifications in the telephone equipment itself. To have done this and to have assured that the equipment retained the same reliability, durability and compatibility with the equipment that was already installed would have cost more than could possibly have been saved by using a domestically produced material.

Likewise, the principal manufacturers of television receivers were subsidiaries who were also using imported designs, and the same constraints applied to them. The end result was that, although etched and formed aluminum foil was used in large quantities in Canada, a Canadian manufacturer of the material would have found virtually no market. In the meantime other countries, although they may have imported the basic technology, made their own designs of equipment and components, and thus provided the opportunity for the foil producer to become established. Despite the fact that their market developed later than Canada's, they were able to complete the cycle long before us.

The impact that end-product manufacturers can have, or can fail to have, upon the environment for innovation is further illustrated by considering in more detail two major segments of the electronics industry, "communications equipment" and "computers and related hardware". In industrial countries these two sectors are of similar magnitudes; in the eleven major countries of Western Europe in 1970[4] the total market for computers and related hardware was 2.58 billion, against 1.78 billion for communications equipment; in the United States[5] the figures were 4.75 for computers and 1.91 for communications equipment. There is some uncertainty concerning the computer market in Canada, but the best estimates that one can make indicate that the communications equipment market is slightly the larger, with the computer market rapidly catching up.

These two categories of end-products are particularly important for providing the "demand-pull" needed to develop an innovative and viable electronic components industry. A healthy components industry, in turn, can provide the demand-pull for high-grade materials, and thus complete the chain to our resource-based industries. The applications for high-grade materials – e.g., high-purity metals with controlled physical properties, plastics with particular dielectric and moisture-resistant properties – are not limited, of course, to the electronics industry. Of the two end-products mentioned, computers probably offer suppliers the greatest potential for innovation, being more sophisticated, with a technology that is evolving more rapidly.

Because of basic differences in the structures of these two sectors in Canada, their impact on the technological and productive capabilities of the Canadian electronics industry have been vastly different.

The computer industry is totally dominated by subsidiaries of foreign-owned multinational corporations (mostly U.S-based) who depend almost exclusively on their parent companies for all designs and engineering. In their recent brief to the Tariff Board, the Canadian Business Equipment Manufacturers Association stated in part:

"Between 60 and 75% of the manufacturing costs of most computer systems consists of parts and materials furnished by outside suppliers. These parts and materials include such items as basic steel products for equipment frames and exterior covers and such other technically advanced items as integrated logic circuits, transistors, printed circuit cards, and specially designed electrical connectors. As yet, a major number of the integrated circuitry and other components required for the production of advanced computer systems are not available in Canada. In other cases, companies with the necessary technological capabilities cannot or will not produce in sufficient volume to enable Canadian computer production in the volume required for world-wide consumption."

In 1970, this industry imported into Canada $218 million worth of

[4]*Electronics*, McGraw-Hill, December 21, 1970.

[5]EIA, *Electronic Market Data Book 1971: Industry Sales & Trends Through 1971*, Washington, 1971.

electronic computers and parts (including card punching, sorting and tabulating machines). Since the growth of the industry over the past seven years to 1971 was 32 per cent per year, and since the growth rate in imports from 1968 to 1970 was 33 per cent per year, it would seem reasonable to assume that for 1971 those imports would be about $290 million, and that they could reach $380 million in 1972.

Electronic component manufacturers contacted by us did not agree that they "could not or would not" supply sophisticated components of the types that are available from regular component suppliers in other countries. They could not, of course, supply subassemblies or components that are proprietary to a particular computer manufacturer. To put these import figures into perspective, it should be noted that the total sales in Canada, to all industries, of Canadian-made electronic components in 1970 were only $85 million. It is not possible to determine what the sales to computer manufacturers were, but we do know it was only a small fraction of the $85 million. On the other hand, a large part of the $218 million in imports of computers and parts was for parts and subassemblies.

The communications sector of the industry, on the other hand, is dominated by a large Canadian-owned manufacturer (Northern Electric), who is responsible for about one-half the value of shipments of the sector, the remainder being made up of a variety of smaller firms, both Canadian and foreign owned. Northern Electric maintains very extensive R & D and Engineering facilities; its research and development expenditures alone account for about 50 per cent of the R & D performed by the entire electric-electronic industry in Canada. Many of the smaller companies in this field, including many of the foreign-owned companies, also maintain active engineering and development activities.

The performance of this segment is, not surprisingly, one of the best in Canadian science-based industry. In 1970, Canada had a positive trade balance of $37 million in this category (from exports of $190 million and imports of $153 million). This compares with a negative trade balance of $130 million in the computer category.

What is even more significant, though less obvious, is that this latter segment of the industry contributed in a very positive way to Canada's underlying capability in the entire field of electronics, and this for two basic reasons. The equipment produced was, in large measure, developed, engineered and designed in Canada, and thus the intangible, but real, knowledge component of this equipment was also "made in Canada". This activity served to support the teams of engineers and scientists that provide Canada with the power to act in this area; or, in the words of Keith Pavitt, it has given Canada the "ability... to follow, assess and exploit scientific and technological developments" in the field of communications. The second way in which this segment of the industry has reinforced our technological capability is through its effect on its suppliers. Details of electronic components purchases by the group as a whole are not available, but it is notable that in 1970 the consumption of semi-conductors, resistors, capacitors and transformers by just one company (Northern Electric) was about $17.5 million, or nearly 40 per cent of the total Canadian production of these electronic components that year.[6] The relative significance of this "demand-pull" for innovation probably exceeds the percentage of production which it represents.

By contrast, the computer industry, by not making its potential "demand-pull" accessible in the same way to the component industry, does not have a comparable impact. Moreover, by designing and engineering outside of Canada, and by requesting duty-free entry of all components, it ensures that the impact will never be felt!

Because too many end-product manufacturers fail in this way to offer the component manufacturers the "demand-pull" that would allow them to develop both technological and production capability, this segment has become very weak (see Table III.11), despite the efforts of Northern Electric and some other communications equipment companies. The weakness of the components industry in turn renders less viable the entire electronics industry in Canada.

In addition, because it is weak, the electronic components industry cannot provide the pull of demand to stimulate and guide its suppliers, and thus the chain to our resource remains incomplete. We cannot be sure, of course, that if the components industry were supported by the end-product manufacturers it would interact in a meaningful way with Canadian materials suppliers. Component manufacturers could also choose to import fully processed technology and thus break the chain.

For example, if a Canadian manufacturer of tantalum capacitors, in order to reduce quality-control costs, buys tantalum powder only from production lots that his parent has approved for his own use, he will provide zero stimulation for a potential supplier of that powder in Canada. He may in fact, by replacing a manufacturer that would not be technology-dependent, have a negative effect. Canada presently exports tantalum ore and imports high-purity tantalum powder; strange as it may seem, if we want to change that, we may have to start by designing and engineering computers in Canada.

Fragmentation of Manufacturing Industry

As was shown in Chapter II of this report, Canadian manufacturing industry is relatively capital-intensive, yet productivity is not high. This is a direct reflection of the highly fragmented state of many sectors of the industry. Capital, rather than having been invested in a limited number of production units with the size and sophistication needed to be competitive on world markets, has been scattered among a large number of small and inefficient plants. The inefficiency of these plants is due to some extent to an inherent lack of sophistication and the limited capacity of the production equipment that is used; but equally important is the fact that much of the equipment is utilized at well under its normal capacity, because of short production runs or simply because of limited sales. As was demonstrated earlier in this chapter, our market is intrinsically quite small and, therefore, in order to have units of above-critical size, they would have to exist in limited numbers. It is quite clear that we cannot achieve efficient scales of

[6]Data supplied by the Director of Procurement of the Northern Electric Company.

operation if the number of manufacturers of a given product is comparable to that in the United States. Yet in many sectors, with markets between 5 and 10 per cent of those of the U.S., we find that the number of manufacturers in Canada is 50 per cent or more of what it is in that country. In the overwhelming majority of cases, this number is far greater than is needed to ensure active competition or to give the consumer adequate choices.

For example, the pharmaceutical industry, with a total market of $325 million in 1968, comprised more than 60 manufacturers that year[7] – the largest of which, selling under two trade names, managed to capture only 7.5 per cent of the market. Competition among these many producers did not, however, give Canadians advantageous prices on drugs. Quite the contrary; the Special Commons Committee on Drug Costs reported that Canada had some of the highest drug prices in the world. Yet from the evidence presented by the manufacturers, their profits were not excessive. Also, despite the large number of producers (or more probably because of the large number of producers), this industry is one that imports more than three times as much as it exports ($79.8 million of imports versus $25.7 million of exports). It is an industry that does substantial basic research in Canada but finds the Canadian market "too small" to do the engineering development that would be necessary to complete the innovative chain in this country. Thus, basic discoveries made in Canada must first go out of the country, usually to the U.S., for engineering development before going into production.

In the chemical industry, which is particularly plagued by problems of limited scale, our largest company (CIL) has only about 10 per cent of the market and, in total, we have nearly 100 producers.

Similarly, Canada is well endowed with manufacturers of television receivers, having 10, compared to about twice that number in the United States. Here also, domestic prices are comparatively high by world standards and, despite this, the industry has narrow profit margins. The trade balance in television receivers is even worse than in the pharmaceutical industry, and it continues to deteriorate. In the field of major appliances we have nearly as many producers as the United States (up to 12 for some appliances) who are, on an average, producing at about 10 per cent of the level of their U.S. counterparts. In small appliances the number of manufacturers ranges from 5 to 10, again only a little less than the U.S. We have seven manufacturers of micro-wave equipment, more than a half dozen of resistors – and so it goes.

These manufacturers must divide between them an intrinsically small market which, in addition, is heavily eroded by imports. Let us consider, for example, television receivers; the total Canadian market in 1970 was 890 000 units, of which about 350 000 were imported and 540 000 were made by the 9 Canadian manufacturers in operation that year. This meant an average production of just about 60 000 units per year per manufacturer, which, taking into account that a number of different models must be produced by each manufacturer, is indeed a small production volume by world standards. But it is the 60 000 that is small, not the 900 000 which

[7] DBS listed 151 "establishments", while the Pharmaceutical Manufacturers Association of Canada had 58 active members.

represents the basic market. In the United States, the average producer makes about one-half a million units per year; thus, Canada could support just two manufacturers of average U.S. size. By working just a little harder, or by using a little more ingenuity, or again by working for a slightly lower rates than our southern neighbors, we could hope to compete successfully with three, or perhaps four, manufacturers. It is very difficult to see, however, how we can compensate for the scale advantage that is given by a 10-fold difference in production volume. If the producers were fewer in number, and thus more productive, it would be easier for them to hold on to a larger portion of the domestic market as well as to export themselves. Production per manufacturer would thus be higher for three reasons: a larger share of the domestic market would go to domestic producers; they would be more competitive on world markets; and total production would be divided among few producers. Yet in our policies we often encourage just the opposite; we invite new entrants into the field, apparently believing that this will displace imports and increase employment. In the long term, it produces just the opposite effect. It weakens the industry, permitting easier entry by imports, and thus reduces the opportunities for employment in Canada.

This type of fragmentation also weakens the component and material industries which supply not only the television manufacturers but all the rest of the electronics industry. It is not difficult to find other examples of this kind of "counterproductive investment".

The major appliance industry is not fundamentally very different. The size of the Canadian domestic market ranges from around 300 000 to 400 000 units per year, depending upon the appliance. Imports, although relatively not as important as in the television industry, take a substantial portion of the market. Again, judging by the performance of producers in the U.S. and by the comments of executives in the industry, the domestic market seems to be adequate to support no more than two manufacturers capable of designing and producing goods that could compete on world markets. This is readily appreciated if we consider that the economies-of-scale advantages for an independent manufacturer are likely to be of the order of those estimated for farm tractors[8] (i.e., a unit-cost reduction of about 20% for production levels from 20 000 to 90 000 units per year), and that to these already substantial differences we must add the differences that come from the development amortization charges. It was estimated by one of the executives interviewed that designing and developing a new model of automatic washer costs, from conception to production, not less than $2 million and sometimes as much as $15 million. If such costs are to be amortized over a reasonable period of time, without putting an excessive burden on the price of each machine, the annual sales prospects for the model must be reasonably high (e.g., to amortize $3 million over 3 years with a $10 burden per machine requires sales of 100 000 units of that model per year). Simple evaluations of this type show that, over a wide range of products, we simply have too many producers.

[8]Royal Commission on Farm Machinery, *Farm Tractor Production Cost*, Study No. 2, Queen's Printer, Ottawa, 1969.

Some Consequences of Fragmentation

The most obvious consequences of having too many end-product manufacturers are reflected in the high production costs incurred by the manufacturers themselves. Short production runs and low volume will lead to high material costs, high overheads and low labour productivity due to a lack of labour specialization.

Less obvious, but no less important, are the consequences that fragmentation can have for the capital equipment, material and parts industries which form the industrial backbone and the in-depth strength of any industrial society. More specifically, we refer here to industries such as the fine chemical industries, the electronic components industry, the machine tools industry and a variety of others whose principal function is to supply other manufacturers. Because the end-product manufacturers have short production runs, their purchases will be correspondingly small, and the short production runs, with all the disadvantages implied, will be passed on to the suppliers of parts and materials. Similarly, because there are many end-producers, the suppliers will have to maintain sales, marketing and engineering service activities that are disproportionately large considering their level of production. The existence of many end-product manufacturers will also necessitate, on the part of the material and parts manufacturers, production and stocking of a wide variety of parts, thus further adding to their cost.

Paralleling the problems caused by fragmentation of suppliers, there is the problem of multiplicity of models. For example, there are no fewer than 36 models of "made-in-Canada" toasters, and no fewer than 300 varieties of automobile mufflers, manufactured in this country. We did not attempt to make accurate counts of the numbers of models in other products, but one has only to look around to realize that the variety of models available in Canada is not very different from what is available in the United States. This occurs for a variety of reasons, the most important being advertising spillover from the United States and the transfer of U.S. technology. The variety of models that can be developed in the United States may sometimes reach quite uneconomic proportions, but in general it will be limited by the normal forces of the market to a level which is tolerable. When this number, which is often scarcely tolerable in a market whose GNP is in excess of 1 000 billion dollars, is transferred into Canada, the numbers become quite intolerable. It may be feasible to design, engineer and produce 36 varieties of toasters in the United States, but to attempt to do this in Canada is sheer folly. As Canadians, we will surely have to make the decision whether we consider it more important to have the opportunity of appraising 36 varieties of electric toasters before making our choice, or whether we would prefer to develop a secondary manufacturing industry that is viable and that provides jobs for our citizens.

The Causes of Fragmentation

Those who have some faith in the forces of the market may quite legitimately ask: What could have caused such a situation to develop and, if indeed it has developed, why do not the natural forces of cold economics take their toll and reduce the numbers to more acceptable levels? The answer is mainly in economics of operation of branch plants and technology-dependent subsidiaries. For these "manufacturers", particularly those with U.S.-based parents, the scale at which they operate does not have nearly as much importance as it does for an independent manufacturer. Entry into Canada by American companies is favoured by physical proximity, by market similarities, by advertizing spillovers, and by the general ease of communication. Because of these, U.S. firms can set up production facilities in Canada in slow stages, avoiding risk and minimizing costs. Once established, they have a wide range of options that an independent company does not have. At one extreme, they can do a nominal amount of assembly (or other form of processing) from components or subassemblies imported from a parent or affiliate, while at the other extreme they can establish an integrated unit capable of operating independently of the parent. Between these two extremes a very wide range of options is possible. It is these options that make it possible for branch plants and subsidiaries to avoid, to some extent, the high per-unit costs that come from small-scale production, yet benefit from some degree of manufacturing. At the lowest demand levels the preferred option is simply to import the finished product. This sets the upper price limit of the subsidiary's cost (for just over zero volume of sales) at U.S. cost plus tariff.

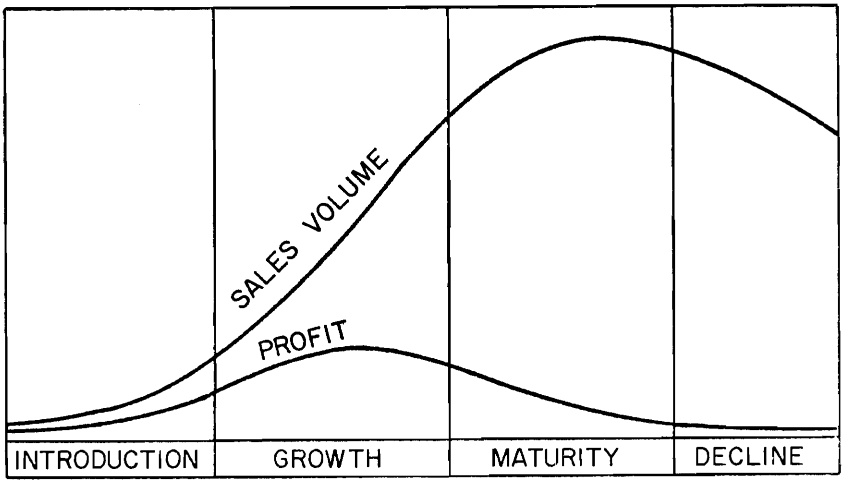
As sales volume increases it will become more economical to do some operations in Canada, and the subsidiary will begin, in a small way to "manufacture" in Canada, continuing to rely on and benefit from the economies of scale of its parent for other operations. Even at the highest levels of production allowed by the fragmented Canadian market, most subsidiaries will continue to import some parts, tools and materials whose costs of production are particularly sensitive to scale. Most will, in addition, import technology, thus benefitting from the economies of scale in this vital area. Because of these economic advantages in manufacturing, and because they may wish to take advantage of advertizing spillover, multinational corporations can find it financially attractive to set up a "manufacturing plant" to serve an already overcrowded market which is driving the independents into bankruptcy. Thus new investment continues to flow into Canada, increasing the number of foreign producers while indigenous manufacturers go bankrupt or sell out. What is perhaps most disconcerting is that these branch plants and technology-dependent subsidiaries, by the very nature of their dependence, can scarcely ever achieve a state in which they can be competitive with their parents or other international competitors on world markets.

Not only does Canada do nothing to resist this process but, through its policies of non-discriminatory support for all comers and through the programs of DREE, IRDIA, DIP, GAAP, it offers positive inducements to accelerate it. These programs have done many useful and constructive things but, because they lack a mechanism for planning and coordination, they have also encouraged a considerable amount of counterproductive investment in Canada in recent years.

Innovation and the Product Life Cycle

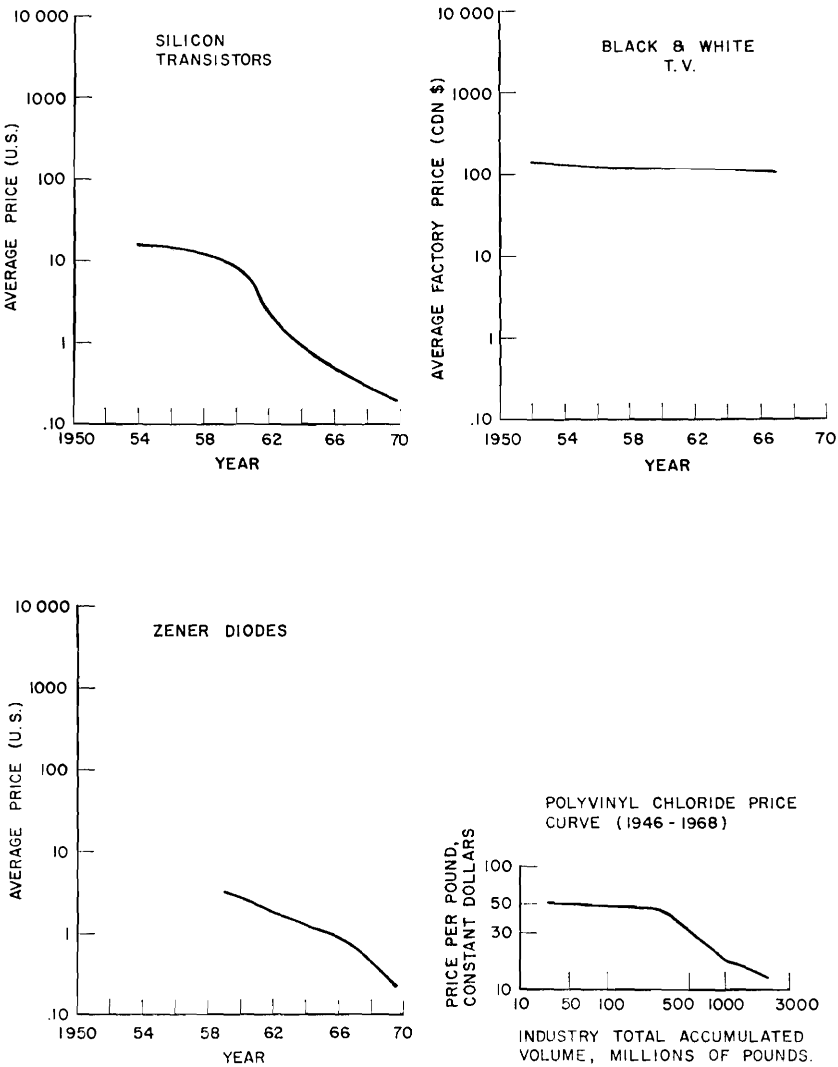
Products generally go through a life cycle in which several phases can be distinguished. Some prefer to distinguish four phases, others five, and still others three. For purposes of the present discussion, it is convenient to distinguish four (introduction, growth, maturity and decline). The duration of the life of a product varies considerably from product to product, but in general it is shortest for the most technologically sophisticated items. The volume of sales as a function of time will generally be as is shown in Figure V.1.

Figure V.1–Typical Variation in Sales and Profit During a Product Life Cycle



During the introduction phase, the sales volume of a new product is necessarily small, and consequently its unit cost is high; its selling price will be correspondingly high. Actual selling prices for a number of products over a period of time is given in Figure V.2. It can be seen from this figure that, in the cases of certain high-technology products, the selling price, from introduction to maturity, declined by more than a full order of magnitude. For other more traditional products, the selling price declines in a less spectacular way. (It should be noted, moreover, that inflation and the tendency to add features each year makes the price decline appear smaller that it is in reality.) This initial phase is characterized by a high level of activity in the development laboratory, in the design and engineering offices, in the quality control laboratory, as well as in the marketing department. During this period, it is normally necessary to continue development in order to eliminate the remaining weaknesses in the product, or in order to refine the development further. In the engineering department, the design of the product is optimized and, in many cases, some modified designs are added to the product line in order to increase market coverage. Evaluation of the product, which would have started before production got under way, is likely to continue for a time, as customer reaction and need are assessed as functions of the product's performance. Production

Figure V.2–Variation in Price of Some Typical Products of Science-Based Industry During their Life Cycles



engineering will be concerned with the development of a commercially viable production process. This can involve the evaluation of machines and equipment for production, it can involve the design and the construction of the production equipment, and it will almost certainly involve such things as plant layout, the elaboration of detailed production or assembly procedures, and a variety of other engineering tasks, the nature of which will depend upon the product involved. During this time, the innovator will normally draw very heavily on the technology and skills available in his environment. Technologically competent suppliers of materials, components and equipment will be very important to him, and in turn he will by his stimulation help them to develop.

The production procedures actually in use at this stage in a product's life are usually very simple and generally quite labour-intensive. In marketing and sales there is a high level of activity taking place to bring the new product to the attention of potential new customers, to assess their needs and to assess their reactions to it. Thus, the combined costs of engineering, production and sales during the early phases of a product's life are usually quite high in comparison to what they will be later on. They reflect mostly the large numbers of man-hours, particularly professional and skilled man-hours, that must be spread over limited production. On the other hand, the capital-intensity and, thus, the overhead due to capital invested is relatively low during this phase. What can be properly identified as manufacturing cost will represent a relatively smaller portion of total cost during the introduction phase than will be the case when the product reaches maturity. The margin between selling price and manufacturing cost will therefore be relatively large, reflecting, in addition to the high costs of engineering, control and marketing, a margin intended to recover the research and development costs incurred previously. As these are largely fixed costs, net profits will rise very sharply as sales volume increases. Thus, we usually find that the maximum in net profits is reached early in a product's life, long before it reaches its peak in the sales volume.

With increasing sales volume, the product passes into the second, or growth, phase of its life. Although competitive products will have appeared by this time, the innovator still has a very substantial advantage over his competitors and consequently he is able to retain a comfortable price level. As a result, production efficiency does not immediately become a critical factor. The costs of engineering, quality control and marketing, while diminishing in relative importance, continue to be very significant in the total cost make-up. Moreover, during this period of its life a product is not sold primarily on price but rather on performance and, as a result, it is relatively easy for it to jump tariff barriers. We should also bear in mind that if the product is a component or material which is to be incorporated into other products it is during the introduction phase and the early portion of the growth phase that it is likely to become incorporated into the designs of the end products. These are therefore critical times in a product's life, for it is through having it designed into other products further down the line that future markets are assured. During the introduction and early growth phases, then, it is vital for a company to have sophisticated marketing and sales personnel, and it is vital that it retain close liaison between its own engineering department and that of its customers.

As a product reaches maturity, competition increases and the pressures to lower the cost of production mount accordingly. At this point the centre of attention becomes the manufacturing process. It will be streamlined, refined, mechanized and automated in order to minimize costs and improve reliability and consistency. As labour costs are usually a large cost item in production, efforts will be made to eliminate the number of man-hours involved in production. This will usually involve the substitution of capital for labour, and the operation will shift toward greater capital intensity. Engineering will become less important, quality control more routine and marketing less sophisticated. With several competitors now offering almost identical products, price, delivery and quality (often consistency) become the important considerations for sales. Transportation costs become important and tariff barriers are more difficult to cross. By this time, exports will have been replaced in many cases by branch plants. Branch plants may also be set up in different regions of the innovating country itself in order to minimize the cost of transportation or to improve deliveries.

The decline phase requires little discussion. The innovative companies will have moved on to better things, and the late entrants will be more concerned with recovering overhead than with making a net profit.

As evidenced by our strong negative trade balance in high-growth industries, Canada does relatively poorly in products in the introduction and growth phases. On the other hand, our level of production of mature products, although not consistently high, is generally on a par with our consumption, and in some cases better (e.g., newsprint, automobile, ammonia, electron tubes, etc.). This relative imbalance in the structure of our manufacturing is no doubt partly attributable to our poor performance at innovation. Another contributing factor is probably our high level of foreign ownership because, as was stated above, it is when a product nears maturity that multinational companies most feel the need to set up manufacturing in other countries.

The consequences of developing a manufacturing industry based on mature products are that it will tend to be capital-intensive, of moderate or low risk, and it will provide a relatively small demand for manpower. Moreover, the manpower demand that it does create will be concentrated in the unskilled and semi-skilled areas, with little demand for scientific and technical skills and only a little more for management skills. These are, to a large extent, the characteristics of Canadian manufacturing industry.

Moreover, innovation and bringing a product through its early life require inputs from suppliers and outlets to customers who themselves have the capacity for innovation and change. An industrial environment characterized by a high percentage of mature industries does not provide these inputs, or outlets, and thus the efforts of the would-be innovator are severely impeded.

The Need for Capital

We have been very preoccupied in recent years with the need to build new manufacturing plants in order to generate jobs for our rapidly expanding work force. Programs that are financially very attractive to anyone wanting to set up shop in Canada have been instituted and we seem willing to encourage and assist almost anyone who wants to build a new plant, regardless of whether or not there is a demonstrated need for such a facility. This policy bears scrutiny, as it is not at all obvious that the indiscriminate building of factories has any beneficial effect on employment opportunities. The premise itself appears to be based largely on a "gut feeling" that if you build a new plant and employ 100 people in it, you surely must have made a net contribution to employment. This, of course, is by no means obvious, for any new plant will interact with, and will influence employment in, its environment. In general, some of these influences will be positive and some will be negative; a new production facility will have the effect of generating additional new jobs among its suppliers of equipment, materials and services, while on the other hand it will reduce job opportunities among its competitors and their suppliers of equipment, materials and services. A new plant will also alter the economic environment itself to some degree. This again may be positive or negative. It may strengthen the technological base if, associated with this plant, there is a high level of technological capability; or it may weaken the technological base because it is dependent upon externally generated technology, or because its interactions are with suppliers outside of Canada. It may serve to fragment an industry, thus reducing the capability of all concerned; or it may have no competitors in Canada and therefore have no such effect. The positive effects will be closely associated with the new facility itself, and thus they are likely to be quite visible. The negative effects, on the other hand, will tend to be more widely diffused in the industry, and consequently they will be more difficult to identify. It is also incorrect to make extrapolations of the effects of new investments assuming constant ratios between the part of the industry concerned and its customers and its providers of supplies and services, because new investments, particularly if they are direct foreign investments, often have the effect of profoundly changing those ratios. For example, a new manufacturer of television sets who imports his components will almost certainly displace existing manufacturers to some degree; if the manufacturers who were displaced were buying Canadian-made components, the level of manufacturing in components will decline and not increase as a result of the new investment. Since the number of employees per dollar of sales is usually higher in component manufacturing than in television set assembly, the net result will be an employment loss – unless of course most of the sales from the new plant will displace imports rather than domestic production. In the present depressed state of the electronic components industry, the loss of even a small portion of the market can have the dramatic effect of complete discontinuation of the manufacturing of a part.

Within the last year, we have seen the establishment in Canada of three new foreign manufacturers of television receivers, one U.S.-based company and two Japan-based companies. The information which we have been able to obtain is that the two Japanese manufacturers are assembling only large-screen colour sets (25 or 26 inches). These are made from chassis imported from Japan to which are coupled picture tubes and cabinets bought in Canada. As there are no large-screen sets manufactured in Japan, these sets are much more likely to come into competition with Canadian-made sets than with Japanese imports. On the grounds that it would create 104 new jobs, one of these new manufacturers has qualified for a DREE grant of $227 000; one cannot but be sceptical about prospective exports from these facilities. The U.S.-based manufacturer also competes directly with the previous manufacturers, and thus contributes to the already widespread fragmentation of this industry without creating any new market.

Many other cases of "counter-productive" investment could be cited.

They most often involve new product facilities based on imported parts which displace existing manufacturers with more vertical integration and/or manufacturers sourcing in Canada. The other most frequent example of counter-productive investment is when unnecessary production capacity is created without an appreciable change in production method. The same quantity of production is then achieved from a larger total investment, thus reducing capital productivity, and the lower scale of operation in each plant also reduces labour productivity.

While all companies would like to have more money, we found few instances in which the larger well established companies were unable to take advantage of good market opportunities because of lack of capital. It would even be fair to say that not one single instance of a missed opportunity because of lack of capital was identified among companies that were at the same time large, in secondary manufacturing, and subsidiaries of foreign-owned companies. For these companies, the available market and the costs of production (including the cost of borrowing) are the important constraints.

Small independent manufacturers present a different situation. Some small high-technology companies are faced with situations in which they must grow at an extremely rapid rate in order to keep pace with a demand which, for some high-technology products, can develop at tremendous speeds. If, as the learning curve predicts, costs decline with the number of units produced, the manufacturer who can develop most quickly will have the lowest costs, and can hold on to his lead. This presents special problems for the Canadian company that introduces a new product into the United States market. If it wishes to remain competitive, it will have to retain a dominant position in that market, and this can require very large amounts of capital, and require them quickly. For the small independent Canadian innovator and manufacturer, getting the necessary capital without selling controlling interest to a foreign company can be very difficult, if not impossible. Something should be done to correct this problem, as it is one which invites takeovers of some of our most promising new companies. If a mechanism to assist such companies is instituted, it should be geared to operate with quite a different order of urgency than do present programs, because the lifetime of such opportunities is much too short to accommodate present procedures.

The innovator who wishes to launch a new company faces essentially the same problems as the independent company, but in much more acute fashion. The private Canadian investor is well known for his conservatism toward ventures in science-based industry (possibly with some justification) and our banks, by both their charters and their internal organization, are not well suited for this role. Governments, while finding it possible to finance, to a large percentage of total equity, foreign ventures in mature industries where there is little evidence of a need for more production capacity (for example, pulp and paper plants), cannot, or will not, give any appreciable aid to the inventor who is trying to get his new venture off the ground. In this area, there is a real need for "innovation" in our financial structures.

The overall impression gained from this study, however, was that the bulk of the Canadian manufacturing industry could benefit more from the incentive of markets than from grants to build new facilities for production. Market availability, not productive capacity, is most frequently the limiting factor.

VI. Conclusion

The preceding chapters have highlighted the weaknesses, the problems, and the failings of Canada. The objective was to identify the obstacles impeding our progress toward the achievement of an acceptable level of technological capability in the private sector, particularly in secondary manufacturing. The picture has not been a bright one; but this picture has shown but a single facet of our achievements, or lack thereof. Consequently it does not give a good image of Canada – and even less of our potential capabilities. The achievements of this country in basic research in medicine, in nuclear energy and in many other areas indicate that there is no fundamental lack of creativity. We have rather failed to utilize this creativity for the achievement of economic objectives.

Canada may have weaknesses, but we also have great strengths: we have a young, dynamic and highly educated population; and we are one of the world's richest countries in resources. These are the two pillars upon which we must build for the future.

Building on People

As was mentioned in Chapter IV, Canada has one of the most highly educated populations in the world; moreover, we have in operation one of the finest networks of universities, junior colleges, technical schools, high schools and elementary schools to be found anywhere. As was pointed out by the Economic Council[1], Lamontagne[2] and others, Canada's work force is expanding extremely rapidly – so that "its growth between 1965 and 1980 will exceed that of Britain, West Germany and Italy put together". This must not be thought of as a liability, as some imply, but as a great asset. The vast najority of those entering our work force will be young, and on the whole they will be well educated. As a result, Canada's work force, which is already one of the most highly trained in the world, will make even greater gains in this respect. It will also mean that, at a time when the average age of workers in many developed countries is near a record high and getting higher each year, Canada's average worker will remain relatively young for the next two decades. What our work force may lack in experience, it will more than make up for in energy and training. Moreover, workers are also consumers, and young workers setting up new households, are particularly large consumers of goods produced by the manufacturing industries. Thus, the "employment problem" created by this rapidly expanding work force will be largely self-correcting, provided we maintain the health of secondary industry.

Most experienced businessmen who are involved in high-technology industries will concede that the strength of a company lies more in its employees than its physical assets. Yet this fact often appears to be overlooked in Canada. In our policies and in our programs aimed at industrial development, we seem to give more importance to the capital, the plant and the equipment than we do to development of the people who provide the knowledge inputs to make them run. We have given large grants to multi-

[1]Economic Council of Canada, *Fourth Annual Review*, Queen's Printer, Ottawa, 1967.
[2]Canada, Senate Special Committee on Science Policy, *op. cit.*

national corporations so that they may build factories which are little more than four walls and a roof, in which to house easily transportable production machines, run by unskilled or semi-skilled production workers. Such plants, unaccompanied as they are by the functions requiring higher skills, are of extreme vulnerability. When grants are taken into account, some companies operating from these plants could move out with a loss equivalent to perhaps a year of rent and a week or so of training per assembly-line employee. In addition, most of these plants are subsidiaries of multinational corporations and their capabilities are duplicated in other countries; the facilities in the home country are usually also larger and more efficient than those in Canada. The risks involved in placing ourselves in such a vulnerable position have been made painfully clear in recent months by the passage in the United States of the bill setting up DISC, and earlier by that country's imposition of an import surtax. The most stable and permanent investments are those based on people and those which constitute the source of the managerial and technological inputs into a company.

In our complex, modern society providing the managerial and technological inputs for a technology-based enterprise requires more than just having a number of trained and competent individuals. It requires that these individuals learn to function in a complementary way and as a well coordinated team. Such a team requires a long time to build up, and once it is acquired it represents a large investment; its value as a team far exceeds the sum of the values of its component members. Not only must the members learn to work harmoniously as a unit, but, more difficult still, they must become coupled and finely attuned to the broader outer environment in which they operate. Only in this way can they get the necessary inputs and effect the meaningful outputs that are essential to success in the world of high technology.

We must build such teams in order to utilize the latent potential of our human resources. We must build them carefully and deliberately in areas where we choose to excel; having built them, we must recognize their value and not allow them to be dismembered because they were not "low bidder" on a particular occasion. There have been many examples in Canada where a capability – in aircraft, in computers, in space communications – was developed at great cost, and subsequently senselessly dismembered or left to disintegrate for lack of support. Without wishing to enter the debate on whether the error was in the selection of which capability to develop and where to develop it, or whether the mistake was not to continue to support it once it existed, it is clear that such inconsistency has been very costly for Canada.

Many senior executives of industry expressed the view that an area of weakness in Canada is availability of skilled managers. Only recently have Canadian universities been giving serious attention to this very vital aspect of professional training, and even today it receives less attention here than in the United States. The problem is aggravated by the fact that, at the present time, there are relatively fewer people in the age group which would normally be entering senior management positions than there are in other age groups. This is a direct reflection of the low birth rate during the depression years. It has also been pointed out[3] that multinational corporations often do not have all corporate activities represented in Canada, and thus they often do not provide an ideal training ground for managers. We should unquestionably place more emphasis on the development of management skills.

Building on Resources

Canada's other great area of strength lies in its natural resources. With competition as keen as it is in the world today, each country must seek to take maximum advantage of those areas in which it has some comparative advantages. This, however, must not be interpreted to mean that we should further accelerate our already precipitous rate of resource extraction. Unquestionably, this latter approach, coupled with massive infusions of foreign capital, could keep our GNP rising for a number of years; but before the children of today could reach middle age most of the resources would be gone, leaving Canada with a resource-based economy and no resources.

Many would agree, however, that one of the avenues open to Canada is to "build on our resources" by adding more value before exporting them. This route, while basically sound, must not be thought of as being an easy one. "To build on our resources" is not a simple task and it is not one that can be undertaken without regard for the end-product industries.

Despite apparently obvious advantages in aluminum, asbestos, nickel, platinum, silver and a host of other minerals, we are net importers of these in fabricated and semi-fabricated forms. This is seen by reference to Table III.16 in Chapter III as well as to Tables A.1, A.2, A.3 and A.4 in the appendix. Semi-fabricated materials based on resources require for their development the "demand-pull" of the industries that use them. As in the cases of other products it is extremely difficult, if not impossible, to launch them first on export markets. At the present time, that "demand-pull" in Canada is very much smaller than the intrinsic size of our market would indicate. Because we do so little of our own design and engineering, there are too few customers from whom would-be innovators in semi-fabricated materials can get direction, stimulation and incentive.

In this connection it is remarkable how companies involved in first-stage fabrication from Canadian resources will usually do all or part of the product development in countries other than Canada. Some notable examples are:

Alcan	– does a large part of its product development in the U.K.
Inco	– does most of its product development in the U.S.
Johns Manville	– all of its asbestos development is in the U.S.
Handy & Harman	– silver product development is in the U.S.
Englehart	– all research on platinum is performed in the U.S.

[3]Arthur J. Cordell, *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy*, Science Council of Canada Special Study No. 22, Information Canada, Ottawa, 1971.

The reasons for this are quite clear. New products are developed in response to needs, and needs for parts and semi-fabricated products will always appear first where end products are developed, engineered and built. In Canada, the requirements and specifications for new parts and materials are likely to be known to the potential innovator *a year after* they are in use in production, rather than *2 years before*, as it is the case in the country where the product is engineered. Companies engaged in development of these parts and materials cannot wait that long, and thus they move their laboratories out of Canada.

Therefore, in order to succeed in "building on our resources" it will be necessary to correct this very fundamental weakness. It will be essential for Canada to *develop* and *exercise* product engineering and design capability, and this at all levels, from end-product to resource.

This design capability must have two characteristics; it must be continuous in as many places as possible so that the "demand-pull" may be transmitted all the way down to the resources; it must be sufficiently broad-based that there will be real strength to the "pull". On both counts there is no reason for complacency; things will not of themselves improve "as our economy becomes more mature".

Fifteen years ago we were developing highly sophisticated military aircraft, but that capability no longer exists; ten years ago we had some limited capability in automotive engineering, and today that multi-billion dollar industry provides virtually no stimulation to innovation in the industrial infrastructure; a little over a decade ago, a Canadian company designed and built a large computer comparable to the best available at the time, and that too has vanished from the scene; within the past five years, the development and engineering capability of our chemical industry has withered very visibly. The structure of our industry being what it is, the amount of engineering and design done in Canada could well continue to decrease as computers play increasingly important roles in engineering, design and quality control.

We cannot, of course, ask manufacturers to "re-invent the wheel" each time they make a new product – nor can we force them to buy only Canadian-made and -engineered parts and materials. Without going to these extremes, however, we can and must find means to correct those structural faults within secondary industry itself which virtually force it into a position of having to rely on imported engineering designs. We must also provide the incentives that will lead end-product manufacturers to design and build the new products truly suited to our needs. We will further have to ensure that the manufacturers themselves behave in such a manner as to transmit the incentive down the line, and that they do so in a way that does not discriminate against those companies which do have an independent mode of operation in Canada.

If we succeed in building an industrial infrastructure that has vigour, it will produce new products and new processes. Some of these will be closely tied to our natural resources and, because of the advantages that this will confer, these resource-based products will be more likely to become important export items on world markets. In the meantime, the end products and products of intermediate level will be supplying more of our domestic market and providing jobs for a work force that is not only growing in numbers, but also becoming more highly qualified and, if well utilized, more productive.

There is a great deal of building to do. We have the resources to do it! Do we also have the will?

Appendices

Supplementary Data on Canadian Trade in Some Resource-Based and Some Science-Based Products

Table A.1–Canadian Nickel Trade, 1969 (In Thousands of Dollars)

Products	Exports	Imports	Balance
Ores, concentrates, matte & speiss	152 594	14 829	
Nickel & nickel alloy scrap	16 905		
Total crude materials	*169 499*	*14 829*	*154 670*
Oxide sinter	55 812	—	
Nickel anodes, cathodes, ingots, rods	215 116	29 768	185 348
Total semi-processed materials	*270 928*	*29 768*	*241 160*
Nickel alloy ingots, blocks, rods and wire bars		1 992	
Nickel & alloy plate sheet and scrap		9 745	
Nickel & nickel alloy pipe & tubing		2 266	
Nickel & alloy fabricated materials, n.e.s.	10 963	2 785	
Total nickel & nickel alloy fabricated materials	*10 963*	*16 788*	*—5 825*

Source: Canadian Minerals Yearbook, 1970.

Table A.2–Canadian Aluminum Trade, 1969

Product	Exports	Imports	Balance
	$000	$000	$000
Ores & concentrates	2 356	97 972	— 95 616
Aluminum & aluminum alloy scrap	17 280	4 970	12 310
Total crude materials	*19 636*	*102 942*	*— 83 306*
Pigs, ingots, shot, slab, billets, blooms, etc.	450 155	2 258	
Total semi-processed materials	*450 155*	*2 258*	*447 897*
Castings & forgings, bar, rods, plates, sheets, etc.	18 355	65 411	— 47 006
Aluminum foil or leaf converted foil	318	2 637	— 2 319
Aluminum paste & powder		715	— 715
Aluminum & fabric aluminum n.e.s.	5 923	10 936	— 5 013
Total fabricated materials	*24 596*	*79 699*	*— 55 103*

Source: Canadian Minerals Yearbook, 1970.

Table A.3–Canada: Trade Balance in Paper and Allied Industries, 1971

	Exports	Imports	Trade Balance
Newsprint	1 084 282	0	1 084 282
Paper for printing	51 926	8 494	43 432
Wrapping paper	22 265	3 174	19 091
Paper boxes	36 142	20 509	15 633
Writing and reproduction paper	15 094	7 700	7 394
Fine paper	2 760	1 373	1 387
Manifold paper and onion skin	0	527	— 527
Special industrial paper	110	4 264	— 4 136
Coated paper	486	4 814	— 4 328
Tissue and thin paper	57	6 646	— 6 589
Converted paper	12 439	23 401	— 10 962

Source: DBS, "Exports by Commodities", and "Imports by Commodities".

Table A.4–Canadian Platinum Trade (Total of 1968 and 1969)[a]

	Exports $	Imports $	Balance $
Ores and concentrates	69 331 000	—	69 331 000
Platinum metals & scrap	24 397 000[b]	26 377 000	— 1 980 000
Platinum metals and fabricated materials	—	6 852 000[c]	— 6 852 000

[a]There were wide fluctuations between these two years, with the average of the two being more consistent with past patterns than either one or the other.
[b]Includes re-exports (material undergoing no change in Canada) worth $13 500 000.
[c]Includes platinum crucibles.
Source: Canadian Minerals Yearbook, 1969.

Table A.5–Canadian Asbestos Trade, 1969

Products	Exports	Imports	Balance
	$000	$000	$000
Crude asbestos & asbestos fibres	*216 275*	*1 425*	*214 850*
Brake linings & clutch facings	1 246	5 137	— 3 891
Asbestos & asbestos cement building materials	1 564	2 355	— 791
Asbestos & Asbestos Cement Basic products n.e.s.	1 251	2 002	— 751
Other asbestos manufactured products (cloth, felts, sheets, packing)	000	2 200	— 2 200
Total manufactured asbestos	*4 061*	*11 694*	— *7 633*

Source: Canadian Minerals Yearbook, 1970.

Table A.6–Canadian Chemical Industry, 1970

	Export	Import	Balance	Strength Index Balance/Market	Ave. Annual Growth Rate (1965-1970)
Pharmaceuticals*	25.7	79.8	− 54.1	−12.0%	13%
Plastics & synthetic resins*	66.1	155.4	− 89.3	−22.8%	9.4%
Toilet preparations	1.6	10.3	− 8.7	− 5.7%	7.3%
Other chemical industries*	36.1	161.2	−125.1	−23.0%	6.9%
Agricultural chemical, formulated insecticides & rodenticides*	2.8	17.3	− 14.5		
Adhesives*	1.1	6.3	− 5.2		
Ammunition	3.9	3.1	0.8		
Chemical modified oils, fats, waxes, etc.	4.6	28.5	− 23.9		
Industrial chemical specialties	23.7	106.0	− 82.3		
Soap & cleaning compounds	0.9	8.2	− 7.3	− 2.8%	5.0%
Paints & varnishes	1.3	17.1	− 15.8	− 6.1%	4.9%
Industrial chemicals	275.3	330.9	− 55.6	− 6.6%	4.5%
Inorganic	117.3	143.5	− 26.3		
Organic	67.7	130.4	− 62.7		
Fertilizer chemicals	88.3	11.7	76.6		
Dyestuffs, pigments*, lakes and toners	2.0	45.3	− 43.3		
Mixed fertilizers	11.6	2.1	9.5	+12.0%	− 4.7%

*Products considered to be above average in science intensity

Source: Canada, Department of Industry, Trade and Commerce, *Chemical and Chemical Product Statistical Review*, Programmes Division, Chemicals Branch, March 31, 1971.

Table A.7–Comparative Performance of the Canadian Electronic Components Manufacturing Industry as a Function of the Degree of Sophistication of the Product, 1969

Type of Component	Canadian Factory Shipments	U.S. Factory Shipments	Ratio Canada/U.S.
	$ Millions	$ Millions	× 100
Passive Components	30.5	1 173	2.6
Resistors	13.0	402	3.2
Inductors & transformers	8.0	281	2.8
Capacitors	9.5	490	1.9
Active components	47.3	2 157	2.2
Electron tubes	39.0	1 252	3.2
Semi-conductors	8.3	905	0.92
Integrated circuits	0.0	498	0.0

Sources:
–EIA of Canada, Publication for Members.
–EIA. *Electronic Data Book, 1971: Industry Sales & Trends Through 1970*, Washington, 1971.

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