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	Report No. 15
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Innovation
 in a Cold
 Climate:
The Dilemma
of Canadian
 Manufacturing

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Information Canada Ottawa, 1971

October 1971

The Hon. A.W. Gillespie, P.C., M.P., Minister of State for Science and Technology, House of Commons, Ottawa, Canada.

Dear Mr. Minister:

In accordance with sections eleven and thirteen of the Science Council Act, I take pleasure in forwarding to you the views and recommendations of the Council as they concern the growth and development of the Canadian manufacturing industry, particularly that part of it which has a high innovative potential. These views and recommendations are presented to you in the form of a report entitled Science Council Report No. 15, "Innovation in a Cold Climate: The Dilemma of Canadian Manufacturing".

Yours sincerely,

O.M. Solandt, Chairman, Science Council of Canada.

Summary

A deterioration has taken place in Canadian manufacturing over the last four years. While some industries (mainly those producing food and clothing) have managed to maintain their place in international trade, many science-based industries are now producing fewer goods than in 1968, and have considerably fewer employees. During this period, their profits declined even more rapidly.

This deterioration places many of our recent investments-in education, in borrowed capital, in social welfarein jeopardy. Our resource industries cannot fill this gap by themselves; nor can our service-producing industries, which depend on a profitable manufacturing base.

An improvement in Canada's economic climate will undoubtedly help manufacturing; the Science Council is concerned, however, that many manufacturing industries may not survive long enough to take part in this recovery. Employment of Canada's labour forceamong the fastest-growing in the industrial world-is at stake.

The Science Council has come to the conclusion that reassessing our industrial policy and formulating an industrial strategy for Canada are essential first steps. In this strategy, it must be recognized that technological innovationleading to the increasing use of skilled workers rather than manual labourersis crucial to meeting our social and economic expectations. At the same time, we must honestly confront the many impediments to innovation that now exist in Canadian industry, and overcome them as best we can.

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Introduction

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Almost 1.7 million Canadians are employed in this country's manufacturing industries. These industries span the technological gamut, from sawmills to telecommunications equipment manufacturers. Over the last ten years, however, most of the new employment in manufacturing has been in medium- to high-technology companies—those producing transportation equipment, electrical and electronic goods, and specialized machinery, for example. In contrast, the number of people employed by food and clothing companies has remained almost constant at 1961 levels.

Between 1961 and 1967 manufacturing employment increased almost 25 per cent. In 1968 this growth began to falter, and employment has now remained essentially static for the last two years. This development can be traced to a levelling off (and in many cases a decline) in employment in precisely those industries that contributed most heavily to new employment in the first half of the sixties.

Our stock of scientists, engineers and technologists in Canada has not remained constant. On the contrary, it is now increasing very rapidly, at a rate of 9 per cent each year. During the last two years about 25 000 newly-graduated scientists and engineers, and perhaps 10 000 technologists, became available for employment.

Part of the reason for declining employment in high-technology industries is, ironically, technology itself; companies have applied technology to achieve increases in productivity. This enables them to produce the same volume of goods with fewer employees. For it is a fact that we are producing no more medium- or high-technology products today than we were in mid-1968.

Even more disturbing is the fact that profits have begun to decline on this fixed volume of technology-based products. This decline began in 1967, and continues unabated in 1971. There is evidence that profits in several industries are now approaching the subsistence level; below this level, a shut-down is inevitable.

It is difficult to offer an unequivocal interpretation of this evidence. It may be, as several authorities have argued, that this down-turn is simply a shortterm fluctuation, that high-technology industry will respond promptly and effectively to an improvement in Canada's economic climate. However, industry based on technology is a relatively recent phenomenon in Canada, and a three-year down-turn has no precedent in its history: we cannot be sure that key sectors will survive to respond as expected.

Again, it can be argued that the history of manufacturing industry contains many examples of industries dying, only to be replaced by new industries. It is significant, however, that in Canada it is precisely those industries from which most was expected—in employment, profitability, tax revenue, and consumer benefits—which are now in difficulty. No new manufacturing industries are in sight, and low-technology industries simply cannot shoulder, alone, the responsibility of meeting our expectations of a better standard of living.

These expectations are founded on an economy in which knowledge, rather than manual labour, is the most profitable component of the goods and services we produce. Our educational and training programs have been based on this premise; substantial sums of money have been spent by governments to establish knowledge-based industries; the continued growth of services (whether governmental or private) depends on a viable manufacturing base. It is the concern of the Science Council that these expectations should be met.

For the last eighteen months the Science Council has had under way a study of Canadian manufacturing industries that are science-based or heavily dependent on science. To complement its analysis of industrial and economic statistics, the Council has surveyed 50 companies that are representative of medium- and high-technology industries in Canada. In the normal course of events the Council would have waited for detailed analysis of this survey and the publication of background studies. The urgency of the situation the Council now sees developing has, instead, prompted this interim report.

The report is in four sections. The first amplifies the reasons for the Council's concern. The next two outline the Council's concept of technological innovation, and trace the origins of the many impediments which now hinder the process of innovation in Canada. The final section suggests ways in which many of these impediments may be removed. The Council concludes that a national industrial strategy is urgently needed, and lists some of the components essential to the formulation of this strategy.

This report is concerned solely with manufacturing industries. Two other studies (an overview of resource industries, and an examination of the use of technology in service industries) are under way; at first examination, these sectors have less acute problems than does manufacturing.

Reasons
for Concern

Many Canadians are concerned about the current lack of new employment opportunities. On the other side of the coin, most industrial employers are troubled by declining industrial growth and profitability. These related problems manifest themselves most acutely in medium- and high-technology manufacturing industry.

Most of today's manufactured products incorporate technology in some form or other. In this report we are concerned mainly with those products that require a *continued and substantial* input of technology. Textile products, for example, are based on technology, but their survival does not depend on a total replacement of this technology by the end of this decade. Many electronic products, on the other hand, constantly incorporate new technology, and their survival in a competitive world requires that this process continue.

One measure of a product's dependence on technology is the proportion of technologically-trained people needed to produce it. Table 1 shows the variation in this proportion throughout a selection of manufacturing industries. In this report our main concern is with the first six industries listed, and the statistical data will refer to this grouping of medium- and high-technology companies. These companies employ onethird of the manufacturing labour force in Canada, and almost one-half of the scientists in the manufacturing sector.

The discussion that follows is not confined to this group of industries,

however. Certain components of the paper and textile industries, for example, are quite technology-intensive. In addition, some technology-based companies employ relatively few scientists and engineers because they are subsidiaries of foreign corporations, and import much of the technology needed for their day-to-day operations.

These, too, are included in our concept of technology-dependent industry, although it has not been possible to include them in the following analysis of recent trends in employment, productivity and profitability.

Employment

Our population can be forecast to 1980, and beyond, with considerable confidence. So, too, can the labour force. We can also forecast many of its characteristics with a high degree of accuracy: almost half of the total labour force growth in this decade will be young adults, markedly better educated than their counterparts in the sixties. The labour force will increase about 2.5 per cent each year during this decade; this is one of the fastest growth rates in the industrial world.

Until recently, employment in manufacturing industry rose proportionately with the labour force. For most of the sixties, a constant 21 per cent of our labour force was employed in this sector. Most of our models for employment are based on the premise that this trend will continue, and that 20 per cent of

Total Employees (1969)	Proportion of Scientists and Engineers (%)
17 050	7.1
76 280	5.1
134 400	4.3
154 480	2.7
76 720	2.6
110 110	2.3
119 620	1.6
77 770	0.8
229 940	0.5
44 860	0.1
	Total Employees (1969) 17 050 76 280 134 400 154 480 76 720 110 110 119 620 77 770 229 940 44 860

Table 1

the labour force will be employed in manufacturing in 1982.

By mid-1971, however, manufacturing accounted for only 19 per cent of the labour force. This departure from projections began in 1967, as Figure 1 illustrates. By 1971, employment in manufacturing had fallen short of expectations by 120 000 jobs.

Several other sectors also fell below the employment model during this period–Canada is at present 180 000



Sources:

(Actual) DBS 72-008: Vol. 6, No. 1 and Vol. 7, No. 2. (Projected) Economic Council of Canada. Staff Study No. 19, 1967 and Systems Research Group. Canada 2000. 1970 jobs short of a 3.5 per cent unemployment rate-but the major failure was in manufacturing.

The service sector continued to grow strongly over the last four years. As Figure 2 shows, employment in private service industries overtook manufacturing employment in 1968, and now exceeds it by a considerable margin. However, the growth in services is not nearly fast enough to take up the unemployment slack in manufacturing.



Over the last ten years, most of the new employment in manufacturing was generated in medium- and high-technology industries. The increases in machinery, transportation and electrical products industries, for example, were four to five times greater than in food, clothing and wood products industries; Figure 3 illustrates these differences. Recent experience has shown, however, that employment in technologybased industry is extremely sensitive to the economic climate. Thus, while food and clothing companies retained their employees despite the difficulties of the last few years, a substantial number of jobs were lost in medium- and hightechnology industries.



Admittedly, some of the employment decrease can be traced to increased productivity: Canadian electrical products manufacturers, for example, now produce 6 per cent more goods than in 1966, with essentially the same number of employees.

A 6 per cent increase in production in five years falls far short of expectations, however, and is far smaller than the world's-or Canada's-increased purchases of electrical products. In fact, as Figure 4 indicates, our output of all kinds of durable manufactured goods (almost all of which are based on technology) has remained essentially constant since 1968, in sharp contrast with our output of raw materials.



Employment of Scientists and Engineers

Of the 60 000-odd scientists and engineers employed in industry, a substantial majority are to be found in the manufacturing sector. Similarly, about 80 per cent of the 7 500 professionals engaged in industrial research and development are also employed in this sector; to date, private service industries perform relatively little scientific research, and most of it is concentrated in the field of communications.

The general lack of new employment opportunities in manufacturing has serious implications for scientists and engineers, particularly since we have increased our output of these graduates three-fold in the last ten years. It is estimated that, in the first half of the sixties, one-half of our university output found employment in manufacturing; of the 25 000 scientists and engineers produced in the last two years, however, probably only 2 000 were needed in this sector to fill positions vacated by deaths and retirements. The majority of our new graduates have so far been able to find jobs elsewhere in the economy, and it is unlikely that serious unemployment exists in this professional group at the moment. However, there is serious doubt about the ability of our governments, our educational institutions, our resource industries and our service industries to continue hiring large numbers of scientists and engineers.

The problem is seen in its most acute form in industrial research and development. Although for many reasons this work has not always led to profitable innovations in the past, the situation is not likely to be improved by abandoning this activity. Yet over the last two years there has been an arrest, and in many cases an actual decline, in research and development in manufacturing industry in Canada. There are indications that this decline may continue over the next twelve months, and possibly longer. Industrial research expenditures began to decline in 1970, despite the increasing proportion of this spending being subsidized through various government incentive schemes. Research budget cuts are now most prevalent in foreign-owned subsidiaries; maintaining yearly dividends is a vital consideration in these companies.

Industrial R & D activity in Canada is still far below that of most other industrial countries. There are no rules for determining optimum levels for this activity, but the current tendency raises serious doubts about Canada's future ability to compete in the world market for technological products; the era of technologically obvious products is over, and in-depth research is more important than ever to maintaining a competitive edge.

There is, of course, little point in doing industrial research simply for its own sake. There are many ways in which a company can achieve technological proficiency, and R & D is one of the means to this end. The disturbing feature of recent trends is that company management-and even, to some extent, public policy-is turning away from this source of proficiency.

There are long-range costs incurred in reducing or disbanding industrial research laboratories. These laboratories represent a long-term investment in human resources. Almost always their total value is greater than the sum of the individual workers, and in real terms there are losses, not gains, associated with disbanding a carefully-nurtured team of specialists. In short, these decisions are not easily reversible; stop-go R & D is costly, and usually ineffective.

It should not be concluded that all those who have chosen training in science and technology should be entitled to employment in the field of their choice. The well-being of the nation requires that effective use be made of highlytrained people in all categories. However, public credibility will inevitably be strained if funds continue to be used to support and promote scientific education, unless more effective use can be made of these graduates.

It is true that other industrial countries are encountering apparent surpluses of scientists and engineers. There are several factors unique to Canada, however-particularly the shape of its population bulge, its low level of industrial $\mathbf{R} \And \mathbf{D}$, and the declining growth and profitability of its manufacturing industry-that foretell a more deeply seated and long-lasting problem in this country. A continuation of present trends will inevitably have profound repercussions on our educational system.

Profitability

Growth, competitive ability and profits go hand-in-hand. All three appear to



be lacking in Canadian manufacturing industry at the moment. The most serious shortcoming, however, is in technology-based manufacturing; as Figure 5 illustrates, before-tax profits in this sector hovered around the \$1 billion level for most of the last decade, in contrast with a gradual growth in other manufacturing, and a sharp increase in service-producing industries. These profits are stated in current dollars, the value of which decreases about 6 per cent each year. In terms of buying power, manufacturing has had progressively less to reinvest over the last six years, and now has fewer disposable funds than at any time since 1958. This progressive decline is shown in Figure 6.

A reaction is already apparent; to



take one example, capital spending by manufacturing in 1971 is expected to be 4 per cent lower than in 1970, compared with an increase of 11 per cent in industry generally. There is a consequent danger that this financial weakness will perpetuate itself, seriously impairing the future potential of manufacturing.

An instance of this impairment can be seen in the matter of pollution abatement. The installation of equipment designed to minimize environmental pollution requires capital expenditures beyond those normally estimated. In some industries, progressively declining profits are producing a shortage of the capital needed to meet federal and provincial pollution standards, and the prospect of an abrupt termination of activities-and employment-cannot be discounted.

The fixed volume of goods being produced and the declining profitability of their producers can be traced in very large part to a common cause: the Canadian demand for these goods is increasingly being met by foreign suppliers. To compound this difficulty, our overseas markets for these goods are gradually being eroded. We investigate the underlying causes in the next section.

Taken singly, these trends in employment, production volume and profitability are discouraging, but not alarming. Similar fluctuations have occurred in the past, and proved to be due to short-term adjustments. In fact, a remarkable performance took place in the sixties-65 per cent in overall economic growth-despite an equally depressing outlook at the beginning of that decade.

Together, however, these trends represent a threat of unusual severity and duration. Additional complications have also begun to appear: U.S. import surcharges, the rising exchange rate, and a possible recurrence of inflation, for example. Because inflation and exchange rates affect our competitive status in 22 export markets-for which 80 per cent of our resource production is intendedrecent changes in these rates have improved other countries' resource exports. However, they are likely to inflict as serious damage on our manufacturing industry.

If these trends continue-and there are no signs in the last four years of their improvement, or even of their arrest-Canada's economy in this decade will increasingly become dependent on the resource and service industries. Resource industries offer limited opportunities for employment; furthermore, much of their profit does not remain in Canada. This funnelling of funds out of the country is likely to stunt the growth of our service industries, which are unlikely in any case to use the very people in whom our most substantial educational investments have been made. Our participation in international trade will become less and less significant, and we will become-once again-mainly suppliers of raw materials to the North American continent.

Innovation

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Within our borders we produce a wide variety of goods, many of them technologically very sophisticated. We should not conclude, however, that we have a world-wide competence or self-sufficiency in all of these fields: we do not. Nor should we view the events of the last few years as a deterioration from a position of technological strength: we have achieved eminence in very few manufacturing industries. Finally, we ought to interpret with great care any improvement in manufacturing that takes place over the next few years: a sense of false security can lead us further astray. For there are some fundamental and structural impediments in Canadian industry that, unchecked, will ultimately worsen our present situation.

To ensure a healthy manufacturing industry throughout this decade, we need better access to markets and capital, improved competitiveness and productivity, more effective managerial skills, better utilization of our work force, and the capability to apply new technology. These goals, and the impediments that now prevent our achieving them, will be discussed in this section. Most emphasis will be placed on the ability to adapt to change through the application of new technology; this concern with the process of innovation springs from the Council's conviction that further advances in our quality of life can come only from the deliberate-and selective-use of technology.

Though widely used, the term "innovation" has many different meanings. Applied to industrial activities, it usually means a conscious sequence of events, covering the whole process of creating and offering goods or services that are either new, or better or cheaper than those previously available. In this report "innovation" means this whole process, from original conception to acceptance in use.

Of course, not all possible innovations are desirable, either economically or socially. There is a limit to the rate 24 at which a society can assimilate even desirable innovations. This report deals only with those innovations that are both desirable and readily acceptable; it must be admitted, however, that innovation assessment is still an inexact science.

Most innovations, of course, are not revolutionary in scope. In fact, most innovation in recent times has been evolutionary, and has occurred through a series of extensions of existing technology rather than as a major discrete step. Despite the dramatic changes wrought by "big innovation", it is important to realize that the sum total of "little innovations" has a greater impact on our society, and that this evolutionary innovation-product improvement, finding new uses for existing products, new means of marketing a product-is an activity that no company can afford to neglect.

Industrial innovation, both large and small, has changed the whole quality of human life in the last hundred years. to a degree quite unimaginable before that time. However, economists are still uncertain about the relative influences of the various inputs to the innovation process. For example, it has become clear that a large, high-quality, national scientific research and development effort, although it represents a kind of national resource, does not necessarily lead to a high rate of innovation: nor does a large population of technologically skilled people. These are necessary, but not sufficient, ingredients for successful innovation.

There are many ways in which an industrial organization can react to a change, to a market challenge, or to a market opportunity. An innovation can be tailored to the organization's particular strengths and weaknesses; it can be designed to fit a special market need; it can be aimed to surprise a particular competitor; or it can be calculated to turn an unfavourable change into a new source of opportunity. The more individual the response, the more exclusive it is and the more difficult it is for others to copy advantageously. It does not necessarily follow, however, that the technology for science-based innovation has to be internally generated. Often a whole new concept originates in recognizing how a piece of existing external technology may be adapted to a new use.

Innovation can be expensive and risky. An organization's particular resources set a limit to the size and frequency of the gambles which it can reasonably take in pursuit of innovation. Other factors must also be favourable for innovation to be a practical proposition. For one thing, the accessible market must be large enough and complex enough to accept and support a high proportion of the innovations that might be offered. Moreover, the accessible market must be capable of yielding an overall return high enough to cover the costs of a reasonable number of unsuccessful innovation attempts, as well as providing the return that justifies the successful ones. If a return of this size is not likely, the number of innovations that can be attempted must drop because the costs of the higher-risk proposals cannot be borne.

This principle-that worthwhile attempts at innovation sometimes fail, and that the consumer should bear some of these costs, just as he shares the benefits of successful attempts-is not properly appreciated in Canada's public policies. A single-minded objective of providing ever-cheaper goods can, in the long run, barm the Canadian consumer.

A great deal of human effort goes into the continual improvement, in terms of costs and value offered, of the goods and services produced by industry. In fact, a major proportion of the total industrial research and development effort in Canada, as in other countries, is carried out for this purpose. This activity produces a continual sequence of minor innovations, from inside and outside sources, in organization, production and marketing, and in methods and procedures generally. However, important domestic and foreign competitors are making similar efforts. Thus, most innovative improvements contribute to competitive equilibrium but cannot be counted upon to provide more than temporary competitive advantage.

In some cases, competitive advantage, rather than simple survival, can be obtained only by displacing the competitive equilibrium more or less permanently. This usually requires a radical innovation, coordinated with a position of strength in the right environment and with the right market opportunity to develop and profit from the advantage. In any country, the industrial research and development effort devoted to this aim is less than that devoted to strengthening existing positions painfully built up in the face of intense competition. Since neither Canadian market opportunities nor Canadian strengths are limitless, only a minor proportion of the industrially important primary innovations in the world can be expected to evolve in Canada. This means that importation of externally developed technologies will always be necessary to strengthen existing businesses and to initiate new ones. Acceptance of this fact does not detract from the importance of innovation generated internally, particularly in the small specialized company taking advantage of opportunities peculiar to Canada.

Foremost among these opportunities is the development of technological products and processes having a bearing on our production of natural resources. Our increasingly skilled population and our wealth of resources are our two fundamental strengths. A successful strategy for industrial innovation must build on both these strengths.

Recent analysis by the Economic Council of Canada indicates that each employee in Canadian manufacturing has an output one-third smaller than his counterpart in the United States. There is a similar difference in output for each dollar of capital invested in the two countries. These differences are usually attributed to Canada's lesser degree of specialization in manufacturing, its smaller markets, its less efficient transfer of technology, and its lower quality of management. As the analysis in the next section

As the analysis in the next section shows, some of these shortcomings are the result of a complex mixture of public and private decisions. Some of them are more easily overcome than others. Their net effect, however, represents a very real threat to the chances of innovation in Canadian industry, and to its likelihood of contributing to our economic success.

Impediments			
to Innovation			

Of the many impediments to innovation discussed below, some are shared by manufacturers in other countries, and some are peculiar to individual industries; many, however, are characteristic of the Canadian situation. This section is concerned primarily with the last category. The major impediments will be considered individually, although in many respects they are related and have common causes.

An Inadequate Technology Base

Most industrially developed countries arrived at their present strengths by gradually developing an infrastructure of technology-based industries. In contrast, the development of secondary industry in Canada occurred in a forced environment of tariff protection, and was greatly influenced by our proximity to the highly-developed industrial complex in the United States. There soon developed a tendency to import technology in the form of finished components or design specifications. This importation of technology has been done mainly through direct foreign investment. It is characterized by a continuous flow of information to the recipient, who does not need to possess the technology in depth, because he is not concerned with its advancement or fundamental modification.

This contrasts with the Japanese method of buying technology as a package. In this case, it very soon becomes necessary to understand the technology; then comes the capability to modify and improve it. The Japanese method is, of course, more costly, but it gradually builds up the technology base that is essential to successful innovation.

It is perhaps necessary to have both types of technology transfer for the satisfactory growth of any industry, but the present balance in Canada is heavily in favour of imported-component technology associated with direct foreign investment. It leads, ultimately, to the assembly-plant type of operation.

Limited Market Size and Market Access

Market size is important in manufacturing: large and expanding markets permit greater specialization and better use of labour, capital and technology. They also help improve productivity, and the preservation of an internationally competitive position. In short, the size of market for a product or process provides the financial motivation and support for innovation. Frequently this motivation is lacking in Canada, despite the opportunities created by various incentive programs for research and development. Two key factors are tariff policies on imports and exports, and the whole host of non-tariff restrictions; there are, however, other factors that are characteristic of the Canadian situation.

While the Canadian domestic market is small, compared with many other countries, it is intrinsically adequate for many kinds of industries. Generally, market size is proportional to a country's gross national product, and on this basis Canada is well ahead of many countries. In addition, sales of durable products are determined by per capita income; here, Canada does even better.

However, our markets are fragmented by too many suppliers. This fragmentation is brought about by the widespread presence in Canada of branch plants and subsidiaries of foreign companies, particularly United States companies. Entry by these companies is favoured by physical proximity, by market similarities, by advertising spill-over and by a general ease of communication. As a result, United States companies can set up production facilities in Canada in slow stages, avoiding risk and minimizing costs. Once established, they can operate relatively efficiently at low production levels because they are able to benefit from some of the economies of scale of the parent organization (for example, technology transferred at minimal cost, bulk buying of materials

or parts, and importation of tools and parts which are expensive to set up). Because of these economies and because they have the backing of strong parents, subsidiaries have unusual "staying power". In this over-crowded situation, it is the indigenous companies that are the first to be squeezed out. The situation is aggravated by our policies of indiscriminate support (for example, through regional economic expansion, IRDIA, DIP, GAAP, etc). These programs are basically well-intentioned, but they lack planning and coordination.

For many products, fragmentation of the domestic market has proceeded as far as it can go. In other industries, this process is still occurring, and should be arrested. New draft legislation concerning a Competition Policy (Bill C-256) is a suitable instrument; it permits mergers of companies where consumer benefits will result from increased efficiency, while at the same time preventing monopolistic activities. The Science Council urges that in the implementation of the proposed Competition Act it be recognized that specialization and scale have growing importance, and that fragmentation has significant disadvantages in the domestic market. At the same time, the Council notes that the sole criterion is that of consumer benefit. It contends that the survival of domestic industries is at least as significant, and that this should be considered in assessing ultimate consumer benefit. Under an enlightened Competition Policy, mergers, joint ventures and other partnership arrangements designed to improve international competitiveness and efficiency should not be discouraged.

As it presently stands, the proposed Competition Act does not contain any positive inducements for mergers or joint ventures. However, it contains provisions that, if used intelligently, can help reduce much of the fragmentation that now impairs Canadian industry. The Tribunal created by the Act must beware of any actions tending to increase this fragmentation. Another way in which we reduce our domestic market is by importation. On a per capita basis we import more than any country except Sweden, and a large proportion of our imports are hightechnology products. It will not be easy to change this practice, for Canada is a trading nation, and we adhere– somewhat slavishly–to the concept of "free trade".

This raises the question of our export markets. The market with the greatest potential for Canadian industry is, of course, the United States. For the most part, access to this market is strictly regulated by tariffs and outright prohibitions. Access to other promising markets is, in the case of subsidiary companies, limited or denied through the international market allocation policies of multinational corporations.

Restriction of market access in this way makes innovation very unlikely in a subsidiary. In the long run, the only way of overcoming this difficulty is through trade agreements: the federal government should seek proposals on future trade agreements which would be designed to increase (rather than decrease) the innovative activities (research, development, market research) performed in Canada in the field of the agreement.

The next two years offer Canada exceptional bargaining powers in negotiating these agreements. There is every likelihood that the margin of preference enjoyed among Commonwealth countries will be revoked as Britain enters the European Common Market; the removal of these constraints will give Canada unprecedented flexibility in future most-favoured-nation negotiations.

In some industries, recent advances in technology have led to substantial economies of scale; the chemical industry is an outstanding example. In many cases, however, the scale is such that markets greater than those available in Canada must be found. Consequently, only by domestic and international rationalization can the benefits of these economies be realized. In the case of the chemical industry, this is contrary to both Canadian and U.S. policy as expressed in current legislation. In other cases, rationalization negotiations are still possible. Especially where Canadian subsidiaries of multinational corporations are concerned, the government should seek more autonomy for the subsidiary in the process of rationalization of output, thus ensuring a greater participation by the subsidiary in all phases of innovation.

The Poor Climate for Investment

Canadians have always tended to save money, and now have one of the highest rates of saving of any country in the world. A great part of these savings goes into bank deposits, pensions, and life insurance; we now have almost as much life insurance in force (\$94 billion) as the entire population of the United States (\$159 billion).

Either through these savings institutions or through private investments, we have a substantial investment in U.S. companies-about \$560 per capita. We have larger investments in Canadian companies, of course, but tend consistently to avoid offering encouragement to the entrepreneur with a new technology-based product; as a nation, we avoid this kind of business risk.

Nor are the larger Canadian financial institutions noted for their enterprise in support of innovative industries. They do, however, supply abundant capital and operating funds to the more established sectors of manufacturing industry. The chartered banks cannot be faulted on this score; safeguarding their investors' funds is an important consideration, and they are legally prevented from acting as risk-taking merchant banks.

It may be that the Canada Development Corporation can fill this gap; under the terms of the present legislation, however, it is likely to be almost as conservative in its investments as the chartered banks. Risk-motivated venture capital companies do operate in Canada, but they are few and their resources are limited. In addition, they and their potential clients suffer from a communications gap: the venture capital companies are concerned-with just cause-about the management of possible new ventures; the Canadian entrepreneurs who approach them seem content with presenting a compelling case for the benefits to be realized, and tend to evade the management issue.

It will not be easy to overcome this set of obstacles. Prudence is a commendable virtue, and the choice for the prudent Canadian investor is often between this country's developed resource industries, and other countries' developed manufacturing industries; for Canada is still a developing country in terms of manufacturing. In contrast, many other countries have attractive manufacturing investment opportunities, and resource investment opportunities do not exist.

It is possible that the new taxation system, with its capital gains provisionsand allowance of capital losses-will help persuade investors to be less conservative. For Canadian capital is in plentiful supply, but is currently avoiding hightechnology ventures to a remarkable extent.

Since the war, governments in Canada have provided millions of dollars to help manufacturing industries; again, the emphasis has been on established companies and established products. The fate of many of the new products coming from federal government laboratories has been sealed, not only by lack of enthusiasm on the part of Canadian industry to take them over, but also by timidity on the part of the government in the face of rising costs and ineffective marketing.

It appears to be time to use another approach: every effort should be made to transfer to industry, wherever practical, any work now carried out in-house by the government that may lead to industrial innovation. This applies particularly to research, development and project management. This transfer of technology will require close cooperation with industry; in fact, proposals should be invited from industry to determine which activities should be transferred immediately.

Generally, while certain governmental measures have served to improve the climate for investment in Canada, the climate is still inhospitable. There remains, too, an air of uncertainty about future government actions and about shifting emphases in our industrial policy. The net effect is to discourage the imaginative and aggressive use of the investment funds available from both domestic and foreign sources.

These difficulties apply particularly to small companies, no matter how great their potential. Both federal and provincial governments should explore the possibility of creating new mechanisms for supplying capital to new and small companies. It may also be necessary to help underwrite their management and training costs. In the last resort, it may even be necessary to insure the loans made by private venture capital firms. Ideally, however, direct governmental intervention should be kept to a minimum; given a more favourable environment for investment, the totally private system should work perfectly well.

In conjunction with this approach, both levels of government should take whatever steps are necessary to remove the barriers that now prevent all kinds of financial institutions from participating in enterprises based on technology, involving at times a high degree of risk, but which show distinct promise in domestic and export markets.

Inadequate Management Skills

There is unquestionably a need to improve the professionalism of Canadian management. In fact, if manufacturing industry is to grasp the new opportunities arising in this decade, it must totally review its existing management development programs.

This applies equally strongly at other levels of manpower development. Improving the quality and skills of industrial employees is essential to maintaining high productivity and competitiveness in world markets. It is also essential to take advantage of the vastly richer manpower resources now becoming available in Canada.

In many ways Canadian graduates are the equal of any in the world. In terms of industrial employment, however, it is becoming clear that there has been a mismatch between the universities and the marketplace. Too much professional training, and not enough education, takes place in universities; this concentration on training produces one-dimensional graduates with little appreciation of the management skills which are a vital asset at any level in industry. There has been an over-emphasis on producing generators of information, and not enough stress on putting existing information to work.

The modification of educational policies is a lengthy process. It is already taking place in Canada, however, and there is little doubt that teachers, graduates and employers now understand one another better. At the same time, it must be recognized that industry itself has an important educational and training function: at the present time it is probably retraining twice as many people as are enrolled in governmental retraining programs, and it may well need to be subsidized if it is to continue in this training role.

Management skills, however, are the crux of the matter; without them, all other skills are wasted. Many areas of Canadian corporate planning are illdeveloped by international standards, but the planning of management development is almost non-existent. This may not harm us over the next few years, but it is—in the long run—one of the most serious threats to the survival of industry.

Improper Location of Industry

Because of Canada's large size and the peculiar distribution of its population, the geographic location of plants can be of great importance. The difficult task of picking the right location is often made much more difficult by regional incentives to locate in a particular area. In many of these areas the ability of a plant to compete is considerably reduced.

This is particularly true when a government-subsidized industry, located in a less-developed province, further divides an already fragmented market. The intensified competition that results can harm, or even destroy, both the new company and long-established companies. In the long run, establishing non-viable industries does not provide employment, but simply moves unemployment from province to province.

There is a place for small-scale manufacturing in the less-developed provinces, as the success of many companies attests. Manufacturing industry is not, however, the ultimate solution to the development of these areas, since it fails to make use of their inherent advantages. Where manufacturing is clearly not viable, government subsidies should be used to develop resource-based and service employment.

Tariff and Non-Tariff Barriers

The question of tariffs is a complex one, on which opinions vary from industry to industry. In general, however, there is a desire to see tariffs lowered. Of much greater concern is the elimination of the non-tariff barriers with major trading partners. These barriers are many and varied, and in part depend on the particular industry; some of the most significant are import quotas and licences, concessional financing, antidumping regulations, specific prohibitions, government purchasing policies, international trading policies, export subsidies, and outright prohibitions. 32

Sub-critical Size and Stability

The great majority of industrial innovations either originate or are nurtured in research and development laboratories and associated engineering facilities. To be effective, these teams must achieve a critical size (this size, of course, varies from industry to industry), and they must mature and maintain some stability. This is difficult, if not impossible, where the industry is fragmented. The lack of this size and stability in Canadian industrial laboratories is a serious impediment to innovation.

The Multinational Corporation

The multinational corporation is, in itself, neither a threat nor a blessing. It is, rather, a fact of economic life. It has spread with remarkable speed over the last fifteen years, and may be expected to grow still more in this decade; for each of the next ten years, it is estimated, world GNP will increase 5 per cent, world trade about 7.5 per centand multinational corporations about 10 per cent.

These organizations are dedicated to their own survival rather than to any one country's national goals. There are, of course, means of reaching an accord between a corporation's goals and those of the country in which it does business. In very many cases, however, multinational corporations are still controlled from within one nation, and frequently they are bearers of that nation's policies wherever they operate.

Nevertheless, the true multinational corporation optimizes its operations throughout the world, and national interests form no part of its ultimate goal of increased efficiency and profitability, even though they may be involved indirectly in steps towards the major company goal. The optimization process may or may not coincide with national aspirations for a component of the system to contribute maximum economic and social benefit. It is the rules set by individual governments that determine how closely the national goals and those of the multinational corporation coincide. Changing these rules with a single objective (such as increasing exports, or increasing R & D) does not necessarily result in an operation that optimizes social and economic benefit to the nation.

It is important to have a clear understanding of the management structure of the multinational corporation before drawing conclusions about research, development and innovation in subsidiaries of these organizations. In technology-based manufacturing, there are several patterns of operation. One is the semi-autonomous (or replica) subsidiary, which engages in a wide range of activities similar to those of the parent operation. Another is the rationalized subsidiary; this produces one or several product lines, as part of an internationally rationalized operation. Although these types predominate, some subsidiaries combine both characteristics.

A major distinction between the two types of subsidiary can be seen in their research and development activities. In the semi-autonomous subsidiary, R & D tends also to be semi-autonomous-typically, scaling-down production technology for the Canadian market, or technically adapting the product to Canadian tastes or climate. In the rationalized subsidiary, R & D is either nonexistent, or (in some cases) a highly specialized operation; in this case the R & D is not necessarily related to the products the company manufactures in Canada, and has little direct relevance to the Canadian economy.

In fact, in either case R & D has little impact on the Canadian economy unless it forms part of a complete innovation chain. While this innovation chain is present in the international firm, it may not be present in any particular subsidiary of the firm. For example, many subsidiary operations that conduct

R & D have no design capability; in other words, they lack the ability to design, develop, engineer and manufacture a product to fill a particular Canadian need. This "design gap" is most evident in the rationalized operation; here the research under way may have no relevance to the product actually being manufactured in Canada. R & D in rationalized subsidiaries is merely a selected component of the central research program. Innovations arising from such research can be developed and produced in Canada, the country of the parent company, or perhaps in a third country.

The semi-autonomous operations appear to be less closely linked to central research, and represent a much greater potential for innovation in Canada. Some of these R & D operations, however, appear to be less than "critical" in size. There are other potential problems which act to inhibit innovation: the lack of adequate design and engineering capability, for example, and an inability to get a clear mandate from the parent company to allocate research resources into specific new areas. There is also a reluctance to rely on Canadian scientific expertise; problems tend to be solved by working with the parent laboratories, and personnel travel back and forth to effect an intra-company transfer of technology.

The situation is quite different in another link in the innovation chainmarket research and other marketing activities. In almost all cases the parent looks to the subsidiary as a source of marketing information, and it is not unusual for 90 per cent of this information to be developed within the subsidiary. However, most market research departments in subsidiaries take a narrow view of their potential role. They limit their activities to identification of those products produced by the parent firm which can be introduced in Canada. This is especially the case in subsidiaries controlled from the United States. In general, market research and marketing

departments maintain very close links with their counterpart departments in the parent firm.

The true role of market research is to identify a needed new product, relate this need to R & D, and (in concert with the responsible corporate departments) design, test, engineer and set up the pilot operation on the new product. A market research department with a more limited view represents a gap in the innovative chain.

Generally, subsidiary operations in manufacturing have been set up in Canada to service the Canadian market. Little thought has ever been given to the use of Canadian operations as a spring-board into other world markets. (A minor exception is in the use of the Commonwealth preference tariff.) Where there are exports, they are usually allocated, especially in the case of the rationalized subsidiary. This market limitation, combined with other gaps in innovation in the Canadian subsidiary, means that successful research and development done by the subsidiary does not necessarily result in the complete innovation process with production in Canada. The rigidity of this structure, and the consequent weaknesses in design and engineering, undoubtedly inhibit the growth of an infrastructure of high-technology industries in Canada.

There seems to be a trend in Canada (as, indeed, in most parts of the world) away from a semi-autonomous subsidiary which manufactures a wide range of products similar to those of the parent company, and which maintains a wide variety of activities complementary to the parent company, to a rationalized production concept consistent with a view of Canada and the United States as one North American market.

The Auto Pact is an example of the new trend. This pact was an industrial production arrangement arising from an international agreement between the United States and Canadian governments; it had as its primary objective

redressing the trade imbalance in automobiles between the two countries. It is, in essence, a production rationalization rather than a product rationalization agreement. As a consequence, it did not confer any autonomy on Canadian operations, and appears to have removed our chances of developing management and design skills in automobile manufacture-and in related industries producing automobile components.

Future rationalization agreements must have multiple objectives: redressing trade imbalances, obtaining specific product mandates, autonomy for Canadian operations in their designated fields, and the development of design and management skills in this country. These agreements will, of necessity, be broader in scope than previous agreements. In the past, with the notable exception of the Auto Pact, Canada has concentrated on the resource industries in its trade negotiations. The time has now arrived to include high-technology industries, and to provide them with better access to industrial markets through broad trade negotiations encompassing both the resource and manufacturing industries.

These trade negotiations will inevitably affect the subsidiaries of multinational corporations. Under a negotiated North American product rationalization concept, for example, we should expect longer and more specialized production runs taking place in Canada, with lower costs, and more shipments to the United States and possibly abroad. Canadian research and development operations, and general capacity for innovation, should be strengthened by the terms of the agreement.

Without these negotiations, simple encouragement of production rationalization by multinational corporations in Canada will make it impossible for Canadian companies to compete in many more fields than at present. Alternatively, with a continued lowering of tariffs, we may well find that production rationalization will proceed no further-that

multinational corporations will optimize their activities by simply shipping finished products into Canada.

In summary: although the multinational corporation is a potential impediment to Canadian innovation, it can also confer benefits through a flow of otherwise inaccessible information. It offers the opportunity of producing specialized goods for a sizeable proportion of the world, and at the same time of becoming foremost in innovation in that specialized field. This can, however, only be done through the use of appropriate government incentives and international agreements.

At first glance, the development of Canadian-based multinational corporations seems a reasonable complementary strategy. The difficulties are formidable, however. To be successful internationally, these corporations must build on the base of a strong domestic market, and the present fragmentation of this market is an almost insuperable obstacle. Further, it is common experience that the management and innovative activities in these corporations tend to gravitate to the region in which their largest markets are located, and can be retained in Canada only through specific government incentives. The Canadian-based multinational corporation is not a universal solution.

	Removing the Impediments					

An Industrial Strategy

Like most other industrial countries, Canada has industrial objectives. Countless business and governmental decisions are made every day, hopefully in accord with these policies. Unlike many other countries, however, Canada has never explicitly stated an overall industrial policy. From time to time, various segments of it are promulgated: a policy for the textile industry, for example, or for automobile production.

As a consequence, we have a variety of individual industrial strategies. Some of these effectively cancel one another out, others are mutually incompatible. It is now becoming clear that this patchwork of strategies often fails to support the very industries most likely to satisfy national expectations; this happens, not by design, but by default. All too often, national support is used to rescue failing industries instead of to back viable ones.

The formulation of a coordinated industrial strategy is not the responsibility of the Science Council; it is, in any case, beyond the scope of this report. There are, however, certain components of this strategy on which the Council can speak with authority.

In formulating an industrial strategy, we must recognize that Canada has two intrinsic strengths—its growing population of skilled people, and its store of natural resources. Both of these strengths can be made to work in our favour in an industrial strategy that stresses mediumand high-technology manufacturing in fields related to our production of resources.

The precise balance to be struck between these primary and secondary industries is a topic on which the Council is less qualified to speak. Many complex decisions must be made: resource industries need more capital, but manufacturing industries can potentially employ more people; resources may produce a more stable economy, but manufacturing can contribute more **38** taxes. In addition, it is necessary to consider the need to conserve many of our resources for optimum usage over many decades. These are, essentially, political decisions.

So, too, is the matter of balance of international payments. For the last ten years Canada has consistently had a favourable balance of trade; on average, each year it has exported goods worth \$400 million more than total imports. A trade surplus of this magnitude is precarious to maintain, since it is also an objective of every other country to export more than it imports. Preserving our balance of trade, and at the same time keeping the Canadian dollar relatively stable, produces international constraints. One consequence is that increased export of finished goods from Canada (or, for that matter, smaller imports of these goods into Canada) must, in the long run, imply smaller exports of unfinished products. The appropriate balance is a political decision that only elected governments can make.

This applies equally to another important component of any industrial strategy-the provision of employment opportunities for all Canadians who wish to work. Only governments can decide on the precise mix of unskilled, semi-skilled and highly skilled jobs that will best meet Canadians' expectations. The Science Council has concluded, on the basis of the best available evidence, that the creation of technology-based employment offers, over a five-to-ten year period, the best multiplier effect: employment of unskilled and semiskilled workers will not follow immediately, but will certainly develop in succeeding years. Without this multiplier, we face the prospect of erosion of unskilled employment as the world's established industries increasingly adopt automation techniques.

While formulating industrial policy is the business of governments, its realization through an industrial strategy must be a cooperative enterprise, involving both industry and government. Here there are grounds for concern, for the relationship between industry and government in Canada is by no means good enough to ensure that this cooperation will take place.

This obstacle to realizing an industrial strategy is the fundamental impediment to successful industry in Canada; most of the impediments discussed earlier arise from this unwillingness to cooperate. Resolving this problem is essential, and imposes specific responsibilities on both government and industry.

The Role of Government

Governments in Canada have failed to harmonize their policies, even at the federal level. Most policies serve many objectives, of course, and priorities often are sensitive to short-term considerations. Commercial policy, fiscal and monetary policies, resource development policies, competition and consumer policies, welfare policies, regional and manpower policies, all serve ends other than simple industrial development. This mismatch among responsibilities is a consequence of a system of government that does not give full control of policies for an industrial strategy to any one minister.

The federal government, in collaboration with the provincial governments and with industry, should develop a coordinated industrial strategy which recognizes the significance of innovation and gives priority to industries of high innovative potential. The strategy should be a national one, and should be incorporated in the terms of reference of all government departments and agencies. The provincial governments should have every encouragement to cooperate in the implementation of the strategy, but a central point in government should be given the mandate for leadership in developing its full implementation.

We cannot emphasize strongly enough that the industrial strategy must be coordinated: among federal departments; between provincial and federal governments; and among industries. Little such coordination presently exists. We also stress that the strategy must be developed *in concert with* the private sector and the universities-not merely discussed with them. The only successful strategy will be a participatory strategy.

This is not to say that useful contributions to the process of encouraging industrial innovation are not now being made by governments; they do, however, lack policy integration. Without this coordination many otherwise useful measures will be self-defeating or ineffective. The federal government's incentive programs for industrial research and development offer a significant support for the early stages of the innovative process (research, development-and lately, some aspects of market assessment); they may be regarded as inducements to innovate, but they do not provide the essential motivation for the whole process of innovation, involving engineering, design and marketing. A national industrial strategy should enhance the effectiveness of these R & D incentives in promoting innovation, and a gradual shift away from incentive schemes should be possible as the strategy makes innovation a profitable concern.

A governmental incentive to industrial innovation that has been little used is the negotiation of trade pacts. By providing greater market access, trade pacts involving Canadian technology-based industries can materially assist the innovation process. Preferably, these trade pacts will be broad, and will encompass both resource and manufacturing industry. However, much will depend on the commitment of *all* government departments to the intent of these pactsincluding those departments that seemingly have little connection with industry.

Negotiation between companies (particularly between parent and subsidiary) is more common than negotiation between governments, and has at least equal significance. Government can help strengthen subsidiaries' negotiating powers by stating-more clearly than it has to date-the responsibilities a subsidiary owes to the Canadian economy.

The need for a national industrial strategy, with commitment by all levels of government and all departments, is nowhere more evident than in questions of regional development, where federal policies on energy and trade (or innovation) may conflict with provincial competition for industry. This regional competition for industry encourages market fragmentation, a serious impediment to innovation. Close consultation by governments, committed to a national strategy, could resolve these conflicts and produce mutual benefits.

It has been argued that the government should provide support for the whole innovative process, but to do this would require public equity in the venture. This may be advisable in certain situations, but there are alternative approaches when dealing with multinational corporations. These would involve negotiation for market access and for the type of rationalization which offers the greatest degree of innovation potential.

Government services account for a significant proportion of our GNP. Used intelligently, in conjunction with high materials and performance standards adapted to Canada-wide codes, the purchasing power of governments could be used as a powerful tool in any industrial strategy. This purchasing should be extended to the purchase of research and development services from industry and the transfer, wherever possible, of present in-house government programs to industrial laboratories on a contract basis. Wherever possible, governments' purchasing powers should be used increasingly as a tool for implementing the national industrial strategy.

In this connection, we direct special attention to those government departments that are in least direct communication with industry. Here anti-industry sentiments are frequently strongest, and there is little appreciation by these departments of their influence on in-40 dustrial strategy. We recommend that these departments reassess their priorities, and suggest that the purchasing criteriaproduct performance, country of origin, and price-be applied, in that order.

Major Programs, as outlined in Science Council Report No. 4, represent one of the most promising approaches to the stimulation of innovation in industry. The Council considers it of vital importance that the federal government make firm commitments on those Major Programs which have already been identified, and provide the initiative and support necessary in the early stages of their development.

The most feasible means of embarking on these Major Programs is through intermediate, yet large-scale, projects. The scope of these projects can be defined to ensure that they will lead in the same direction as the Programs; indeed, they will form component parts of the Programs, but have a specific orientation toward creating totally new industries in Canada.

Besides government, industry and universities* must be involved in these programs. Especially in the early stages, Major Programs will need firm government commitment and support if they are to generate their full economic and social benefits.

The federal government has also the power to stimulate innovative industries by taxation policies and by the use of non-tariff barriers. These powers must be related to the policies of other industrial nations and to the need to give equivalent support in specialized areas in order to compete.

The Role of Industry

Canadian industry is by no means a homogeneous group with common objectives. Very frequently it seems that the only topic on which it can reach a

^{*}The University contribution to innovation in Canadian industry is not evaluated in this report. Cooperation between industry and universities is an important subject for later consideration.

consensus is the inadequacy of government. Industry, too, needs to set its house in order. Specifically, industry should seek to establish improved machinery for reaching within itself an imaginative consensus concerning optimum industrial strategies for Canada and for developing more effective communication with government. It should marshall better industrial information and analysis and present these more cogently and effectively to governments and to the public.

We recognize that an industrial consensus is more to be striven for than achieved. Competition between companies is inherent in the free enterprise system, and it is understandable that different industries should have opposing views on what actions governments should take. Nevertheless, a better consensus than presently exists must be achieved.

Several obstacles must be overcome. The prevalence of foreign-owned subsidiaries totally dominates the viewpoints expressed by a number of industrial associations, and it must be recognized that these are not necessarily "Canadian" attitudes. Many industries must begin to accept that business freedom is also freedom to fail, and that government– while it can spur on the successful–should not constantly supply crutches to the failing. Above all, industry must work to overcome its subsidiary mentality, the main characteristic of which is an extremely short time horizon.

Finally, there must be an improved dialogue between government and industry if an industrial strategy is to be implemented. This should be promoted by the opportunity for frank informal, as well as formal, exchanges of views on topics such as those listed above. Joint examination of position papers on these subjects by top levels of governments and industry should be encouraged. The movement of top executives between industry and government should be facilitated.

Conclusions

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The Science Council views with alarm the current deterioration of technology-based manufacturing industries in Canada. While we have avoided a recession in our overall economy, something very much like a recession is now occurring in manufacturing. How temporary an effect this is we do not know; what is certain is that the condition will not improve automatically.

A number of impediments to economic success in manufacturing are likely to persist unless deliberate action is taken to eliminate them. Some of these impediments are structural, and owe their origins to policy decisions made many years ago; their elimination will be a lengthy process. The main impediment, however, is the poor relationship that now exists between government and industry.

If both parties are willing to cooperate, a national industrial strategy can be formulated to produce substantial economic and social benefits in the years ahead. The strategy must be based on our two strengths–a growing population of skilled people, and a rich store of natural resources. Technology-based manufacturing industry in resource-related fields is the key element in a coordinated industrial strategy.

These industries will prosper if innovation is made an integral part of their strategy. To do this, we need to assess the impediments to innovation that now exist in many industries. In some of these industries it may be that we cannot develop the capacity to innovate; in others, the sole impediment may be lack of will.

Canada needs manufacturing for many reasons. It cannot afford to enter the post-industrial era without first developing a better industrial economy. And the time for making these crucial decisions is short; the global economy is already imposing specific roles on individual countries. If Canada wishes to become an innovative industrial nation, now is the time to declare its intentions. Science Council Committee on Industrial Research and Innovation

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