

UNLEASHING CANADA'S TECHNOLOGICAL TIGER
OR
CONVINCING THE HORSE TO DRINK

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Introduction

As the saying goes, "You can lead a horse to water, but you can't make it drink". In many ways Canadians are that horse, and the water is the many studies that have been conducted and reported over the past fifteen years that have attempted to raise the alarm that Canadians' standard of living was in jeopardy unless significant changes were made to the economy and our educational system. For the most part Canadians have been ignoring or discounting the message contained in these reports to increase our investment in science and technology, technological innovation and entrepreneurship; they have not been drinking it in.

The recent report on Canada's ability to compete in a rapidly changing global economy by Michael Porter of Harvard University (Porter, 1991) is simply the most recent in a string of reports by individuals and organizations such as the Science Council of Canada, the Economic Council of Canada, the National Advisory Board on Science and Technology, and the Corporate Higher Education Forum warning that Canada must make some fundamental changes in the structure of our economy or risk losing the many qualities of Canadian life, such as our medicare system, that we all enjoy and take for granted. These reports have all indicated that Canada must increase its investment not only in science and technology, but also in all the elements that would increase and improve our ability to develop and employ new technologies and create new industries in many sectors of the Canadian economy.

To make these fundamental changes in a timely manner, certain underlying issues must be addressed, certain barriers to making these vital changes must be overcome, otherwise all our efforts to increase productivity in existing industries, to develop the new industries capable of competing in the 21st century and to develop the specialized workforce required to sustain a modern industrial economy will continue to be frustrated, and future prosperity for Canada will forever be beyond our grasp.

This paper will not address all of the issues that the many studies have identified in order to focus on those few that will more directly impact on the utilization of science and technological innovation in producing a vibrant, productive economy in the 21st century.

Among the issues or barriers that this paper outlines are the underinvestment of Canadian private industry in research and development and technological innovation; the inadequate quality of management of technological innovation and technical entrepreneurship; the decline in interest of our young people in careers in science, engineering and technology; our low level of investment by venture capital firms in fledgling high-medium technology companies; the low level of adoption of new technologies by Canadian manufacturing firms; the inefficient linkages between government and university R&D activities and the new process or product development efforts of Canadian industry; and the lack of confidence displayed by Canadians when faced with the option of buying Canadian developed technology.

There is, however, one issue that stands above all others. It is the one that has defeated all previous attempts to improve Canada's science and technological innovation capability in the past. It is the issue that reinforces and condones the issues and barriers mentioned above. It is the one that allows the federal government to eliminate the Science Council of Canada without fear of a public outcry. Canadian's do not believe that our ability to develop and utilize science and technology has any bearing on their pocketbooks.

ISSUE #1

INCREASING CANADIAN'S UNDERSTANDING OF THE ROLE OF SCIENCE AND TECHNOLOGY IN FUELING A MODERN ECONOMY

This single issue underlies most of the problems that Canada has in moving toward a more productive and wealth producing future.

Individual Canadians, are for the most part, ignorant of the role that science and technology plays in supporting a modern economy. They are unaware that our competitors are not going to beat us with cheap labour, but with more effective use and application of science, engineering and technology.

In the executive summary version of his report, Michael Porter in explaining why he thinks Canada has not made much headway in moving towards becoming a more effective global competitor states, "Perhaps the most important factor in Canada's ability to move forward is the attitudes and the mindset of individual Canadians" (Porter, 1991, p. 99). In subsequent television interviews, Porter said that he thought that that was 50% of Canada's problem. HE IS WRONG. It is 80-90% of the problem.

Simply put, most Canadians, be they credit managers, factory workers, university professors, school teachers, lawyers, janitors, bankers, college instructors, bureaucrats, company presidents or politicians do not really believe that science and technology can have a major impact on Canada's economic well-being. They consider that science and technology is something other countries conduct; they consider that science and technology plays only a marginal role in determining their quality of life. As a result, we underinvest in research and development, we make little attempt to learn how to manage technological innovation or technical entrepreneurship properly, we do not hold our scientists, engineers and technologists in high regard, we do not reward or recognize their contribution to Canadian society with the result that fewer students view a technical career favourably, we do not recognize that investment in new high-medium technology firms is an investment in future wealth creation, we believe that adoption of new technology to increase our productivity or development of new products or processes is not necessary, and we do not make sufficient effort to link the direction and R&D output of our government and university laboratories with the technological needs of the private sector.

As noted by others, each of these problems or failures reinforce each other. A lack of initiative by industry to develop new products/processes reduces the need for: links with other laboratories; for investment in R&D, marketing, manufacturing - elements important to the technological innovation process; for technical graduates from colleges and universities, for supporting services from other technology-based firms or organizations, or for timely adoption of new technologies.

Unless individual Canadians understand that their prosperity will depend for the most part on the intelligent utilization and development of science and technology in Canada,

they will restrict the potential solutions to improving our competitiveness to easily accomplished, financially impoverished, band-aids. If a person thinks they have just a minor ailment, they will ignore it or make only superficial efforts to cure it; if, however, they think it is life-threatening, they will take all measures necessary to increase the probability of a cure. Right now our lack of investment in science and technology is looked upon as a minor ailment; this must change for our economic survival.

The issue facing Canada must be to determine what actions must be taken to inform and convince all Canadians of the vital role that Canada's science and technological innovation infrastructure plays in determining Canada's ability to compete in international markets, and in maintaining and improving the standard of living that Canadians demand for themselves and their children.

ISSUE #2

INCREASING INVESTMENT BY THE PRIVATE SECTOR IN RESEARCH AND DEVELOPMENT

By almost any measure, Canadian firms do not invest in research and development to the same level as their competitors in other countries. Even when officials from other countries comment on how our underinvestment in R&D will hurt us, our company officials don't believe it. In a speech to the annual convention of the Canadian Pulp and Paper Association, Olle Alsholm, President of the Swedish Pulp and Paper Research Institute, said that the Canadian pulp and paper industry has neglected research and development by investing only 0.3 to 0.4% of sales in research and development while Swedish firms invest double that amount. A Canadian official defended the Canadian industry's record saying it was "not out of line with other countries". (The Ottawa Citizen, January 31, 1992, p. C7).

Some Canadian organizations do recognize that our ability to compete in international markets is deteriorating. The Canadian Manufacturers Association in their report on how to keep Canada competitive points out that, "the lack of commitment to industrial R&D by Canadian industry is a clear indication that CEOs in many Canadian companies are not measuring up to what is required in today's competitive environment" (CMA, 1987).

Without a change in strategy by Canadian firms, the prediction of the World Economic Forum 1990 that Canada will rank 19th out of 23 industrialized nations in projected growth in R&D expenditures over the next five years, will come true.

Canadian managers must realize that even in times of economic downturn, investment in R&D and the development of new products or processes must be maintained, and even increased. Our competitors are not slowing down. Japanese firms, for example, believe in maintaining R&D expenditures during times of economic pressure. One Japanese R&D executive stated that he was criticized by his superiors when he proposed cutting his R&D expenditures during a downturn. He was told that, "research is the doctor who must cure the patient" (Research-Technology Management, January-February, 1992, p.3).

Canadian managers, of firms of all sizes, must realize that the utilization, adoption or creation of technology must be an integral part of their business strategy if they are to improve productivity, successfully compete and survive.

The issue for Canada is to arrive at some consensus as to how Canadian corporate managers can be convinced of the need to increase their commitment to science and technology, and technological innovation within their firms.

ISSUE #3

IMPROVING THE QUALITY OF MANAGEMENT OF THE TECHNOLOGICAL INNOVATION PROCESS IN CANADA

A hospital would be horrified if a person presented themselves as a brain surgeon, without any medical training whatsoever, but organizations appear to take it for granted that anyone, without management training, can manage one of the most complex areas of human endeavour, the development of an idea into an new product or process, that finds success in the marketplace.

A major barrier to Canadian firms increasing their commitment to science and technological innovation is the fact that most of the boards of directors, chief executive officers or even middle or low level managers have had little or no training or education in what is, and how to manage the technological innovation process (Science Council, October, 1988). This lack of knowledge can also be found in senior bureaucrats in both federal and provincial government departments and agencies. This lack of understanding of how to manage the technological innovation process can start with the promotion of scientists or engineers into the first level of management in their organization's R&D laboratory without "one minutes" training in R&D management. The inability to appreciate the strategic role that science and technology plays in a company's ability to achieve business objectives can also occur when a person who has come up through accounting or finance is promoted to the position of Chief Executive Officer of the firm, and believes that success comes only through cost cutting and being more efficient in what you do. Efficiency is not enough when the customers are crying out for new products or processes to solve their problems.

With scientists and engineers, the problem starts in our universities and colleges when they fail to educate their students on the importance of managing scientists, engineers and technicians in the most effective way. To make matters worse, our present educational system encourages and reinforces a certain arrogant attitude among scientists and engineers that there is nothing to learn about managing technical personnel or the technological innovation process. This attitude leads to the reaction of a senior R&D manager when advised that he was to go on R&D management training, "Management training, why do I need management training, I have a Ph.D. in Physics".

It is of little consolation that this lack of preparedness for managing science and technology is not confined to Canada. In a recent review of management in the U.S., the American National Research Council noted that in 1989, only \$1 million was spent in providing management training to people who manage \$67 billion of R&D.

For Canada, the issue is two-fold: to determine how to convince our post-secondary educational institutions to increase their efforts to equip scientists, engineers, technicians and business graduates with the knowledge needed to effectively manage science and technology, and to convince existing managers in both government and industry, that their ability to contribute to Canada's competitiveness will be determined by their knowledge of how to manage the technological innovation process and the people who make it happen.

INCREASING THE NUMBER OF SCIENTISTS,
ENGINEERS AND TECHNICIANS/TECHNOLOGISTS
AVAILABLE TO CANADIAN EMPLOYERS

Concern is growing that Canada will have a considerable shortfall in the number of scientists, engineers and technicians/technologists in the very near future. The Canadian Engineering Resources Board, for example, estimates that Canada will have a shortfall of approximately 10,000 engineers by the end of this decade. This situation is not unique to Canada, but is being experienced in the U.S., Japan, Sweden and U.K. as well.

This problem has two dimensions: fewer students are enrolling in science and math courses in high school, and subsequently in technical programs in colleges and universities; and the performance of the students who do take the math and science courses in high school is not matching up to that of the students in competitor countries. Data from the Second International Mathematics and Science Studies, for example, showed that Canadian students finished near the bottom of test scores.

Several studies have suggested that both the quality of the teachers and the early year's curriculum in the school system contributes to the reduction in the number of students both qualified and interested in going on into post-secondary studies in science and technology. Studies by the Science Council of Canada show that "more than half of all early-years teachers, and more than a third of all middle-years teachers, have never taken mathematics or science at the university level (Science Council, April 1984). A more recent review of why students were not enrolling in the technology programs of Ontario community colleges suggested that one of the reasons why students, especially males, were turning off science after Grade 8 was the emphasis in the primary grades on botany/biology. To the students, more science meant more plants. This focus on botany/biology did not encourage students whose interests were more in the areas of engineering, technology and the physical sciences (Clarke and Reavley, 1990).

Despite attempts to encourage girls to stay in math and science courses, they drop out at a much higher rate than boys. Robert A. Ferchat, President of Northern Telecom Canada Limited noted that, "In Toronto, by Grade 13, two-thirds of the female students have dropped maths and sciences", which excludes them from at least 82 careers for which mathematics is a prerequisite (Ferchat, 1988). A contributing factor to this drop-out is the neanderthal attitude of many school guidance counselors who advise girls to drop math and science since, in their opinion, girls do not need to have it to be successful.

The educational system can not create an interest by students in science and technology; the system can only reinforce an already existing interest that begins to form before a child enters the school. This will not occur if the attitude displayed by one head of a high school science department is typical. He told his students that it was not his responsibility to encourage or interest them in a career in science. Some companies have made efforts in building bridges to local schools to encourage students to retain their interest in a technical career through providing guest speakers, having tours of their facilities, offering summer jobs or providing recognition for student achievements.

In general, Canadian society, and many employers have not taken much interest in the achievements of science students while in school. For example, very few technology-based companies take part in the sponsorship of local, regional or the Canada-wide science fairs

that take place every year. Little recognition by the news media is given to entrants or winners thus reinforcing the feeling that science is not important to Canada.

The demand by employers for graduates of science, engineering and technology programs will also influence the enrollment rate. If a person sees a career in these fields as both interesting and financially rewarding, they will be more inclined to take on the hard work necessary to complete the programs. However, if the rewards for the hard work in college or university are not adequate compared to other occupations, then the comment by one school student is logical: "Why be a scientist when I can be his boss". Janet Halliwell, Chairman of the Science Council, notes that existing data on demand suggests that Canada's demand for highly qualified personnel is more like that of a "semi-industrialized nation" (Halliwell, 1991). If this is true, then fewer students will be attracted to a science or technology career, unless they view such a career as a ticket to enter more dynamic and supportive foreign countries.

Canadian companies are notorious for underinvesting in training for their workers. Studies show that Canadian private industry spends 0.3% of our gross domestic product on training compared to twice that for the Americans, three times for the Australians, five times for the Japanese and eight times that for the Germans (Learning Well... Living Well, 1991, p.6). This problem is against the background of our school system graduating students who are functionally illiterate. It is estimated that 30% of Canadians are functionally illiterate and have poor numeracy skills.

Canada cannot become more productive or innovative without a highly skilled and well educated workforce. Immigration is no longer a source of these workers as their originating countries are also dedicated to improving their economic performance through the exploitation of science and technology. If anything, Canada's highly qualified personnel will be subject to raids by foreign organizations looking to overcome their country's personnel shortfall. We see it already with American hospitals putting on employment exhibitions in Canadian cities to attract nurses.

This issue is multi-layered: what actions can be taken in the primary and secondary schools to improve the quality of math and science education and maintain the interest of students in a science and technology career; what actions can be taken by the educational system and employers to reinforce both male and female student's interest in science and technology, and what actions can be taken to encourage employers to increase their level of investment in their workers.

ISSUE # 5

INCREASING THE LEVEL OF INVESTMENT BY VENTURE CAPITALISTS IN NEWLY ESTABLISHED TECHNOLOGY-BASED FIRMS

Studies by the Science Council of Canada and others reveal that while the venture capital community is quite strong, with about 75 venture groups managing \$3.3 billion in funds, there are no strong links between the venture capital community and technology-based companies in Canada (Macdonald, 1991).

In order for Canada to compete in the 21st century we must nurture and encourage the establishment and growth of technology-based firms. Most young high-growth, technology-based firms require access to sources of outside capital if they are to succeed in penetrating and capturing Canadian and foreign markets.

Unfortunately, the financial support received by Canadian entrepreneurs is less than that received by their foreign competitors. The average venture financing of a Canadian technology company in 1989, for example, was \$657 thousand, which was 65% of the average for French-based firms, 52% of the average of U.K. -based firms, and 30% of the average for U.S. - based firms (Macdonald, 1991, p. 16). Part of the reason for the lower support is the poorer track record of Canadian high technology firms. It is suggested that their poorer performance is due, in part, to underfunding when they were established. Thus, Canadian firms face a Catch-22: they are denied adequate funding until they can prove they are a success, and they can't succeed without adequate funding.

Among the major barriers impeding the creation and growth of high technology firms are:

- the shortage among the newly established high technology firms of experienced, well-trained managers who understand the challenges of managing a high technology firm and marketing technology-based products, processes or services;
- the shortage of experienced Canadian venture capitalists knowledgeable about the technological innovation process, and capable of assisting and guiding the development of emerging technology companies;
- the absence of an adequate number of technology-focused venture capital funds in Canada; and
- the absence of a sufficient number of Canadian or foreign corporations willing to enter into strategic alliances with fledgling Canadian firms and provide them with the benefit of their management experience.

The problems facing Canada that result from this issue are the following: what actions can be taken to increase the number of managerial competent technical entrepreneurs in Canada; what can be done to educate and or train financial managers so that they are in a better position to assess the actual technical and business risk of a new technology-based venture; what actions can be taken to encourage the formation of more technology oriented venture capital funds; and what steps can be taken to encourage more strategic alliances between small technology-based Canadian companies and more knowledgeable corporate partners.

ISSUE # 6

INCREASING THE LEVEL AND SPEED OF ADOPTION OF NEW TECHNOLOGIES BY CANADIAN COMPANIES

Numerous studies have shown that Canadian companies are reluctant relative to their competitors to invest in new technology to enhance their productivity. Part of the problem has been that many firms saw their market as being just in Canada, and because of prior tariff protection have not seen the necessity to become more competitive. A 1989 Statistics Canada Survey found that fewer than half of the manufacturing firms responding to their survey had implemented one or more of 22 leading manufacturing technologies (Prosperity Through Competitiveness, 1991, p. 16). It was also noted that these companies lagged behind their counterparts in the U.S.A.

With the advent of the Canada-U.S. Free Trade Agreement, the market has changed and Canadian firms are now under greater pressure from U.S. competitors to become more productive and competitive.

It has been suggested that a contributing factor to the low level of adoption of new technologies has been the lack of knowledge by Canadian managers in what constitutes, on a global basis, best-practice technology. Another contributing factor is the high cost of capital which makes managers reluctant to purchase new technology when existing technology still works, albeit not to best-practice standards.

Canadians must address these questions: how can Canadian managers be convinced of the need to actively seek out and adopt new technologies; and what can be done to provide Canadian managers with timely information of best-practice technologies available anywhere in the world.

ISSUE # 7

IMPROVING THE LINKAGE BETWEEN GOVERNMENT AND UNIVERSITY R&D LABORATORIES AND THE PRIVATE SECTOR

Canada has only so many human and financial resources that it can spend on science and technology, and the technological innovation process. By working together, the three sectors of the economy can increase the payoff of their investment in science and technology, and increase Canada's productivity and competitiveness in global markets.

Many federal government departments such as Energy, Mines and Resources have established industrial advisory committees to provide guidance to their senior R&D managers in the selection of R&D projects conducted within their laboratories.

With technology rapidly evolving, the linking of industrial laboratories to sources of strategic basic research has taken on greater importance. In a study conducted in Ontario in 1987, 61% of the companies surveyed considered that basic research had been very important to the R&D activities of their firms (Clarke, Reavley and Orpwood, 1987). As universities are the major players in conducting basic research, it is vital that many of the areas of research being investigated are of prospective value to industry. The creation of the Ontario and Federal "Centres of Excellence" is an example of an important initiative in building links between universities and industry. Government laboratories also conduct strategic basic research of value to industry and many have set up offices of technology transfer to move their findings into the private sector.

Despite these efforts, many companies are still in the dark about much of the research going on, even in their local universities. Past suggestions to establish a computer data base directory describing the research being conducted at Canadian universities have not been acted upon.

On the industry side, there must be a recognition of the value of the research being conducted in both government and university laboratories, and an ability to access, adopt and utilize the research results. Numerous anecdotes exist about government researchers or university professors becoming frustrated in their efforts to transfer profitable research results to Canadian companies only to be rebuffed, and the results being taken up and exploited by foreign companies.

Canadians must arrive at some consensus on what actions can be taken to improve the communication and technology transfer links between government and university laboratories, and their counterparts in Canadian industry.

ISSUE # 8

INCREASING THE CONFIDENCE OF INDUSTRIAL AND GOVERNMENT PURCHASERS IN CANADIAN DEVELOPED TECHNOLOGY

Many studies have pointed out the reluctance of Canadian managers to buy technology from small, relatively new Canadian firms. It is almost as if they believe that if it is Canadian, it is second rate and the company will not survive long. Many small, new established Canadian high technology companies report that their first major sales were to U.S. or foreign buyers. Based on their foreign sales, they were then able to convince Canadians to buy their product. Federal government procurement of early products and services has also been an important factor in the success of many small high technology firms.

Michael Porter in his recent study also commented on this risk averseness of Canadian companies to buy Canadian technology. He notes that this has contributed to the weak infrastructure for supporting world class technology based firms.

It has been suggested that one of the main reasons for the reluctance to purchase from Canadian suppliers is the lack of technological sophistication to accurately assess the risks and benefits of buying from the Canadian manufacturer. Because they are not able to assess the technical risk of the product, the risk is an unknown, and therefore avoided by refusal to purchase.

The question for Canada is how can the risk averseness of Canadian technology purchasers be overcome, especially in the case of new Canadian technology-based firms.

Conclusion

In a 1991 study of indicators of national competitiveness in high technology industries, Alan Porter and J. David Roessner report that Canada ranked 24th out of 29 countries in their measure of "National Orientation" which they defined as, "evidence that a nation is taking directed action to achieve technological competitiveness" (Porter and Roessner, 1991). This is a failing mark on anyone's economic report card.

Canadians must drink the "water of understanding" represented by the many warning studies, and realize that we must, as a nation, take the rapidly approaching last off-ramp leading to improved competitiveness and prosperity. To continue straight ahead leads to slow economic strangulation and eventually the inability to make economic course corrections due to lack of human and financial resources.

If our academic, business, and government leaders fail to convince Canadians of the necessity to change economic directions quickly, then one father's advice to his two very intelligent children who are presently enrolled in science, and engineering programs will be voiced by other parents, "I am happy that you have decided on careers in science and engineering, but remember, you have no future in Canada".

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