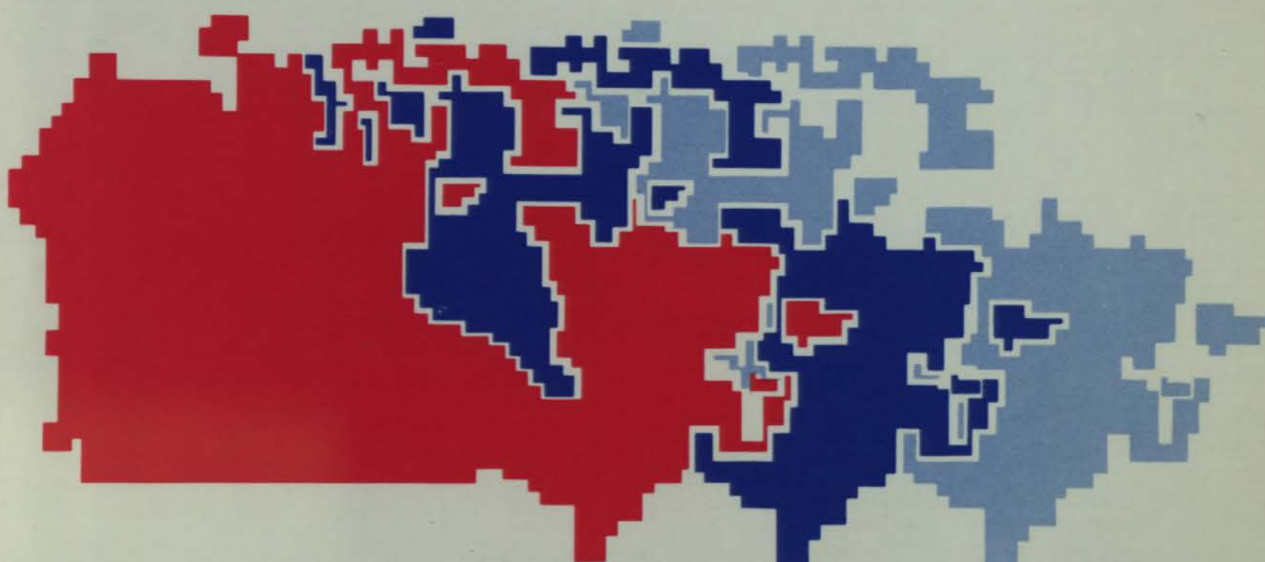
Canada Tomorrow Conference

November 6-9, 1983



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THE CANADA TOMORROW CONFERENCE

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BARRIERS TO THE DEVELOPMENT OF CANADIAN HIGH-TECHNOLOGY INDUSTRIES:

WHO IS RESPONSIBLE?

"The fault, dear Brutus, lies not in our stars but in ourselves that we are underlings."

W. Shakespeare.

1. THE OPPORTUNITIES: INCREASING REWARDS TO GLOBAL ENTREPRENEURSHIP

1.1 The Place of High Technology in the World Economy

Since about the middle seventies, the world's economy has been undergoing a major structural transformation brought about by three forces: a) the energy-shocks of 1973 and 1979 and the responses that they engendered on the part of national governments; b) the rise of the newly-industrialising countries or so-called NICS (S. Korea, Taiwan, Singapore, Hong-Kong, Brazil, Mexico, etc.); and c) the microelectronic revolution.

Of the three, the most important by far is the microelectronic revolution. The first industrial wave occurred with the steam engine in the late eighteenth century. The second came with electricity and the internal combustion engine in the late nineteenth century. The third is now launched with the micro-processor or "ubiquitous chip" altering the modes of production, consumption and the way of life itself.

This third industrial wave is creating *winners and losers* exactly like the previous ones. The winners are those countries which are adapting their industrial structure to the new reality. The losers are those who, for various reasons, are not. It has taken a major world recession and serious setbacks in major manufacturing industries to awaken governments and business in the United States and Canada to a realization that our traditional smokestack industries are very vulnerable indeed to competition from Japan, the newly industrialized countries in the Far East and in South America, and from revitalized European industries.

According to 1982 OECD statistics the United States now stands only 5th in Private Consumption per capita while Canada ranks 11th. These comparisons are made using current exchange rates which tend to reflect a probably overvalued US dollar in relation to the Japanese yen and most European currencies. The highest private consumption per capita is that of Switzerland which averages US$10,128, while the corresponding US private consumption is US$7,370 and that of Canada US$5,950. Japan in spite of an undervalued yen ranks fairly close to Canada at US$5,220. Thus Canada is no longer a high wage country in relation to other OECD member countries, except perhaps in some industries which in the past faced little foreign competition and had the ability to pass higher than average wage costs on the consuming public.

1.2 Foreign Responses to the Challenge

The United States

The basic technology of the information age has largely been developed in the USA. The invention of the transistor at Bell Laboratories 35 years ago has, in an amazingly short span of time, led to the further development of integrated and large scale integrated circuits, memory chips and powerful microprocessors which are the heart of today's computers, robots and modern telecommunications equipment. While today the US lags behind Japan in the field of industrial automation, it is nevertheless true that robot technology has been almost entirely developed in the US. American industry was, however, slow in adapting new technology to the production process.

US multinational firms led the way in moving standardized assembly operations to low wage offshore countries, and most industries were content to continue their reliance on large scale standardized manufacture as the backbone of their business without making any major effort to innovate. US industrial leaders in recent years very often had a financial and business orientation and were more concerned about the rate of return on assets than in promoting innovation. Thus the US steel industry for years paid high dividends while largely neglecting to modernize its productive plants. The concept of providing built-in obsolescense in various products was highly touted as a means of ensuring a continuing market demand for various products.

As competition from foreign producers squeezed profit margins in many industries, many business leaders chose the merger and acquisition route to maintain the economic viability of their organization and became what Robert B. Reich has aptly described as "paper entrepreneurs". There were of course some progressive enterprises such as IBM, the Bell System and various high technology firms that did not fall into the trap of neglecting innovation but even many of these did not devote nearly as much attention to improved manufacturing methods and quality control as did their Japanese competitors.

A major weakness of the US high technology industry has been and still is an overemphasis on short term earnings and efforts to maintain a high P/E ratio rather than on investment for long term growth. The reason for this is that business decisions are almost always made with an eye on the stock market — if the P/E ratio of a company's stock drops in a year due to lower earnings, institutional investors such as pension funds will often get rid of their holdings of that stock, the share price drops and access to new capital may dry up. While the problem is recognized, there is no easy solution to this dilemma.

To some extent Reaganomics and monetarist policies designed to curb US inflation have backfired, in that the resulting high level of interest rates has caused the US dollar to become overvalued. The overvalued dollar has in turn caused a severe loss in the competitive ability of US industry in export markets and has given foreign competitors good access to the domestic US market.

The Japanese Miracle

Japan's genius has been mainly that country's ability to import and sometimes improve upon imported technology and in organizing its industrial productive apparatus to achieve a high level of efficiency. Japanese industry has been highly innovative in devising improved manufacturing processes using automated technology. Much of the success of Japanese industry in world markets has been based on the age old principle of "offering a better mousetrap". While in pre-war days Japanese industry was mainly known for selling low quality dinky toys and cheap textiles and footware, a determined effort by industry and government to dispel that earlier low quality image has been enormously successful. The most coveted prize in Japanese industry is the Demming prize for quality manufacture, named after the American professor Demming whose teaching and promotion of statistical quality control in industry gained wide acceptance in Japan, while his work was largely ignored by American industry. Interestingly enough, Dr. Demming has finally gained acceptance in his own country and now works for the Ford Motor Company.

Much of Japan's success in the industrial sphere may be ascribed to the *low level of adversary activities and the tradition of consensus seeking*. It is illustrative of this fact that there are fewer lawyers in all of Japan than in Washington, D.C., while disagreements between firms and between individuals are often resolved through the intermediation of professional conciliators.

The degree of consensus on industrial goals which has largely guided the development of Japanese industry was generally supported by high tariffs and other visible and invisible import barriers which allowed manufacturers to build their competitive strength in new industries until they were ready to face a competitive world market. Such barriers have been coming down because of intense pressure from other countries and also because they are in many instances not needed, but high import barriers still exist in some fields, especially in agriculture which is a politically very sensitive sector.

Until fairly recently Japanese industries did not excel in R&D but relied mainly on technology transfer from other countries, relying more on their manufacturing ability and marketing skills is gaining access to foreign markets than on innovative skills. These efforts were greatly assisted by the ready access to capital at low cost. The very high rate of savings (about 20%) and the record of Japanese banks of supporting industrial development, often providing as much as 90% debt financing for industrial firms and additional managerial support, have also been important to industrial growth. The Japanese level of R&D spending is now close to that of the US (about 2.5% of GNP), and Japan is now attempting to generate more of its own technological information. Typical of this effort is the ambitious program to develop a fifth generation computer capable of exercising artificial intelligence. Nor should it be forgotten that because Japan has very little defence industry, almost all of this R&D effort is aimed at civilian purposes.

Much of Japan's success in the international marketplace is due to thorough market studies and great flexibility in adjusting product design to suit the needs of particular markets. It is an interesting fact that nearly all of the top industrial leaders in Japan have an engineering background but have widened their range of experience through a series of assignments to various company departments prior to assuming senior management positions. This fact probably accounts for the strong emphasis on engineering and manufacturing technique of these firms. Very often international marketing is performed for a number of different manufacturing firms by one of the large trading companies which are a uniquely successful Japanese form of trading organization.

The Japanese guru of the information age is Yoneji Masuda. In 1972 he authored "The Plan for Information Society — A national goal toward the year 2000" which was a model plan for the realization of Japan's information society. The plan called for realization of the information society by the year 1985. This plan was accepted by the Japanese government, and Masuda was appointed project manager for this ambitious plan.

Another interesting feature of Japanese industry is that major manufacturing firms such as Toyota mainly assemble subassemblies or parts manufactured by specialized manufacturers. These suppliers have a long term relationship with a major manufacturer and provide parts or subassemblies just on time for the assembly function to save the major manufacturer the need to keep large part inventories. This practice is now being emulated by US car manufacturers. Parts manufacturers associated with a particular major manufacturer even have their own associations. There is no indication that the lack of competition for contracts in this submanufacturing sector has in any way led to diminished efficiency or any lessened emphasis on quality, but rather quite the contrary.

A factor worth noting is the great flexibility shown by Japanese industry in abandoning so-called sunset industries and moving into new and more promising fields. Thus while shipbuilding was once a major Japanese industry, South Korea has now become the major shipbuilding nation while Japan has supplied South Korea with the most modern shipyards in the world. Similarly, Japan is moving out of the basic steelmaking business and concentrating on the manufacture of higher valued specialty steels and on building modern steel manufacturing plants for other countries. Thus last year about 55% of Japanese exports were of plants and production machinery while the smaller portion of exports was directed at a consumer market. A reverse trend is also seen, in that Japanese industry which has abandoned most textile manufacture some years ago, now is resuming the manufacture of higher quality textiles using highly automated equipment. The general trend of Japanese multinational companies is to move standardized mass production and assembly operations activities abroad while retaining the more highly skilled R &D, engineering and senior marketing and corporate planning and administrative functions in Japan. The result of such policy is to gradually upgrade both the level of skills and the earnings of Japanese workers, while providing mostly lower paid assembly jobs in countries hosting Japanese offshore plants. This is what occurs when Japanese television sets are assembled in Canada, or when Honda manufactures cars in the US. In contrast to the Japanese somewhat nationalistic MNCs, it is claimed by Robert Reich and others that American MNCs in most instances are exclusively concerned with profit maximization and perform any corporate function wherever this can be done most profitably. This may be true of many US MNCs but in Canada we have too often seen a reluctance of US parent firms to assign world product mandates or meaningful development tasks to their Canadian branch plants.

There is in Japan very little fear of technological unemployment. One reason for this is the strong competitive ability of the Japanese economy, but other factors such as the low female participation rate in the labour force, a low birth rate and virtually no immigration are very important. While young women constitute an important and highly productive workforce in industry, they usually do not keep such jobs much past the age of thirty. According to Peter Drucker, the best advice a Japanese father can give his daughter is to make sure that she is married before the age of thirty. While today more women go on to higher education they can not count on being able to follow the traditional career path of young men being groomed for increasing responsibility in their companies, and are more likely to be empoyed in such occupations as computer programming which are outside of the mainstream of the management career paths. Japan thus remains very much a male dominated society and there does not appear to be any near term prospect that this culturally determined situation will change.

The Newly Industrialized Countries and Less Developed Countries

The practice of industry in developed countries to move assembly work and lower skilled manufacturing tasks to low wage developing countries has assisted these countries in establishing basic manufacturing skills. These developing countries are not content to remain providers of poorly paid assembling operations for long but are striving to develop a higher skill level and their own enterprises. They will then join the ranks of the newly industrialized countries. Thus while the South Koreans may not yet have the skill to design a highly modern shipyard, they do have the skill to build ships in a modern shipyard built for them by the Japanese. It takes a different level of skill to design a highly automated factory and to operate it. Thus Hong Kong today has some of the most highly automated textile plants in the world.

The developing countries fear that automated production in developed countries and a rising level of wages in third world countries will cause most foreign companies to move all production back to their homebase. Nevertheless, it is reported that Japan expects most manufacturing of automobiles to be performed in the developing countries before the end of the century, even though such production will be highly automated. Another factor favouring continued offshore production by major MNCs is that these developing countries constitute a rapidly growing market. It has been projected that well before the end of this century 300 MNCs will handle half of the world's trade, and they are not likely to ignore the growing markets and aspirations of the NICs and the LDCs. There is, however, a real danger that developed countries will increasingly impose restrictions on imports from the third world to protect jobs in their traditional smokestack industries. The Brandt Commission has warned against the disastrous consequences of such policies, and hopefully an upturn in the world economy will lessen this danger.

The oil crisis, recession and high interest rates have brought many of the developing countries to the brink of bankruptcy. The World Bank, the International Monetary Fund and commercial banks all have to make various concessions to avoid default by various hard-pressed countries. The main protection these countries have against national bankruptcy is the fact that the debts in question are so very large that a default by any of these nations would likely lead to the collapse of major banks. It is therefore likely that accommodations will be made to prevent economic collapse. In the future the international banking community will, however, be much more reluctant to invest billions of dollars to foster industrial development in the developing world, and the IMF and World Bank can not provide all the investment capital which is needed. The best hope for relief may lie in more direct investment in offshore plant facilities by major companies in the developed countries.

Europe

The current recession has affected a number of European countries severely. Resentment of US economic policy is high, particularly in France. US restriction on imports of steel from European countries have caused a great deal of friction. There are, however, some signs that an upturn is in sight.

European countries have lagged behind both the USA and Japan in microelectronic technology, but they are catching up. France, in particular, has clearly recognized the need to prepare for an information age. Great efforts are being made to modernize the public telecommunications system and to promote growth in electronic industries — often through joint undertakings with US firms. The Dutch Phillips company had done most of the development on the video cassette recorder but undoubtedly the Japanese will sell more VCRs. The telecommunications equipment industry is fairly strong in a number of European countries and protected by a great many visible and invisible trade barriers. European governments generally work closely with industries in the respective countries, and we are likely to see a revitalization of a number of industries in the near future. It is interesting to note that Sweden has more robots in relation to the size of the workforce than Japan, and that robots made by a small Norwegian firm, Elkem, are used to paint cars in Detroit by two large car producers. Air-Bus Industries — jointly owned by several European countries — has emerged as a major competitor to the US aircraft industry. It will lead too far here to enter into a broad discussion of European industry except to note that the problems of facing up to the realities of the coming information age are much the same in Europe as in North America. In Europe it is more likely that governments will play a larger role in directing the adjustment of the national economies to this new age than will be the case in Canada and the U.S.

Within the European context, the country which has internalized information technology best in its development plans is France, in many ways the closest Western emulation of Japan. Although beset by cyclical problems and the recession, like everybody else, the longterm outlook for high technology development in France is very good.

1.3 Canada's Problem: Unrealised Potential

The challenge now facing Canada is to make a successful transition to a high-technology economy with a minimum of disruption during the transition period. There is probably reasonable agreement that Canada must achieve a higher level of productivity and generally raise the level of efficiency in industry and business to remain competitive in international markets. To quote Peter Drucker: "It is more important to do the right things, that to do things right". In other words, we need to assess where our strengths and weaknesses are, and devise policies to build on strength, and as much as possible remedy our weaknesses.

Canada is uniquely positioned to become one of the industrial world leaders in the new information age. This country has everything needed for industrial success if only we marshal our forces to work towards a common end. Let us count our blessings:

Canada is ideally located between the Atlantic and the Pacific Oceans with harbours on both costs for access to all the world's shipping lanes. Our common border with the US provides easy access to the richest market in the world. Canada is also abundantly endowed with the rich resources of forests, mines, farms, oceans, oil and gas, and hydro power. In contrast with many of our competitors in the resources sector, we also, in most cases, have a transportation infrastructure capable of bringing these resources to market. The Canadian population is well educated, and we have the required educational facilities for providing additional education as required. Canada is also a non-violent society and situated far from any of the world's conflict areas. Internationally Canada has an enviable reputation for fair play and has no enemies. Finally, our ethnically mixed population is potentially a tremendous asset in building trade links with other countries, because Canada has skilled people in almost any field who speak the language and understand the culture of various foreign countries. This is a resource which in the past has been badly underutilized.

Canada's main industrial strength will in the future be in the resources and high technology sectors. Information technology will, however, be employed in all sectors of society — home, office and place of work.

Our resource industries are likely to remain extremely important as Canada's main source of export revenue but will face increasing competition from developing countries. The world market for some crude and fabricated materials will remain weak for years even if the world economy pulls out of its current recession, mainly because new manufacturing methods, and especially the reduced use of steel in car manufacture, has led to a conservation in the use of raw materials. Resource industries are not labour intensive and will in the future have to become increasingly automated to compete in world markets. An upgrading of the transportation infrastructure and improved efficiency in transport industries are also vital to the competitive ability of our resource industries. There should be considerable scope for more intensive efforts to upgrade a greater proportion of raw materials into higher valued fabricated materials and end products prior to export.

In discussing high technology in industry, it is important to make a clear distinction between the so-called high technology industries and other industries which are not in a high technology sector but nevertheless need to employ a considerable amount of advanced technology in order to achieve productive efficiency. Some existing Canadian industries which are now threatened by foreign competition, can remain competitive through extensive automation and improved marketing, or they may be able to reorient their product line to exploit a profitable niche in the market. It makes little sense in most cases to subsidize the operation of so-called sunset industries, i.e. industries which stand no reasonable chance of remaining viable in the face of foreign competition, but government assistance for the retraining of workers, and sometimes short term assistance to enable such firms to enter a different and more promising business may be warranted.

Our high technology industries may never employ a very large proportion of the Canadian labour force, but they will provide the core of expertise which is essential in an information economy. A great many jobs in an information economy which are not directly tied to the production of high technology products, depend on a country's industrial strength in high technology industries.

One of Canada's main strengths in high technology is in the telecommunications field, where Canada is a world leader. This strength is mainly in the design and manufacture of high quality communications carrier equipment and in the telecommunications carrier field as well, but it does not extend to the market for consumer electronics which is dominated by the USA, Japan and South Korea. Nor does Canada have a strong component industry. Our small positive balance of trade in telecommunications carrier equipment is, however, completely dwarfed by sizable trade deficits in the Office and Store Machinery sector which includes computers, and a further deficit in the Electronic Instrument sector. The combined trade deficit for consumer products is estimated at $1 billion for 1983, and from commercial electronics a trade deficit of around $2.5 billion is estimated for 1983. Unless Canada improves its balance of trade in the electronics industries, the deficit of trade in this sector alone will soon exceed $5 billion annually. In 1982 the total export of electronic products amounted to $2,763 million while imports of electronic products totalled $5,615 million. The 1982 total Canadian consumption of electronic products was $7,041 million. These dismal trade figures do not reveal that Canada has a number of promising firms in the various electronic sectors which have considerable potential for growth. Thus AES and Micom are strong in the office automation field, and a number of small computer firms are carving out niches for themselves in selected fields. Canada has also a number of competent and promising firms in the software field. Apart from Bell Canada Enterprises and Mitel, most of the major exporters are subsidiaries of US firms with IBM Canada being the clear leader. These trade figures do not reflect the very considerable spending on R&D in Canada by Bell Northern Research, nor the return received by Bell Canada Enterprises and its Canadian shareholders from Northern Telecom's US subsidiaries.

All told we must realize that there is a great potential and a considerable amount of entrepreneurial activity in the high technology sector which will have to be nourished and encouraged. The success of such firms as Northern Telecom, Mitel, and Canadian Marconi in telecommunications, CAE in flight simulators, and AES and Micom in word processing, are clear evidence that Canadian industry can succeed in high technology.

We do, however, need more than high technology manufacturing. Thus it was estimated that Canada's deficit in fully manufactured articles was $18 billion dollars in 1980 which corresponded to a loss of 400,000 jobs in secondary manufacturing industries. Even though Canada achieved a positive balance of trade in that year, it should be kept in mind that secondary manufacturing is labour intensive while resource industries are not.

The considerable potential described above is however only partially realized and Canadian high-tech firms seem to excel more at the invention than the innovation and marketing stage. Many excellent Canadian inventions came to fruition elsewhere and the crucial passage from inception of an idea to its execution is painfully slow. This brings up the whole question of barriers and what can be done about them.

2. THE BARRIERS: CANADA'S CONFRONTATION ECONOMY AND ITS CONSEQUENCES ON HIGH TECHNOLOGY DEVELOPMENT

It is the thesis of this paper that the principal barriers to high-tech development in Canada are self-imposed and are internal to Canada's socio-economic system rather than external. By "internal" factors we refer to those that are controllable by Canadian actors rather than imposed upon them by some external body. This means that the "foreign ownership" issue long claimed to be the external bottleneck par excellence for the development of high-technology in Canada may well be somewhat overstated.

The Foreign Ownership Issue

The Science Council in a number of reports has dealt with the problems arising from the extremely high ratio of foreign ownership of Canadian industry (about 60%). This is a very difficult issue. The problem is not so much with the concept of hosting some foreign owned companies in Canada as with the preponderance of such firms in Canadian industry. Mel Hurtig in a article in *Canadian Business* in July 1979 wrote that the amount of foreign ownership in Canadian industry exceeded foreign ownership in all European industry by a wide margin. He also based much of his argument for measures to reduce foreign ownership of Canadian firms on a study by Dr. Thomas Powrie, called "The Contribution of Foreign Capital to Canadian Economic Growth", which was shown to be negligible during the period 1950-1976.

Most foreign subsidiaries were established in Canada in past years as a means of climbing the Canadian tariff wall. These plants usually had little autonomy from the parent company, performed little or no R&D in Canada and were not permitted to export in competition with their parent firm. Because of short production runs, they were often high cost producers. The actual economic performance of many of these firms was difficult to gauge because the parent companies could more or less arbitrarily decide what portion of corporate overhead and R&D costs would be recovered from such subsidiaries in Canada.

Some foreign subsidiaries are beneficial to the Canadian economy in that they possess technology and skills which could not be provided by domestic firms.

Thus, for example, IBM(Canada) makes a positive contribution to the Canadian high technology industry and also has a world product mandate to develop and export certain types of equipment. The federal government has had some success in persuading a number of foreign Canadian subsidiaries for some product lines. This normally means that R&D, production and marketing responsibility for a certain line of products is assigned to the Canadian subsidiary. Several foreign subsidiaries in the aerospace industry, e.g. Garrett Mfg. Ltd. in the aerospace industry, similarly have world product mandates.

The Foreign Investment Review Act created an agency to screen applications from foreign companies wanting to establish Canadian subsidiaries or take over ownership of Canadian firms. Such applicants were required to meet some criteria such as promising to perform R&D in Canada, export some of their factory output and generally act as good corporate citizens, as a condition for obtaining the approval of F.I.R.A.. None of these requirements are unreasonable, especially so in the light of the very high degree of foreign ownership in Canadian industry, and most applications are approved. Most foreign countries, including the USA, put far more obstacles in the path of foreign takeovers than does Canada, but from the outcry against F.I.R.A. from the US and some other countries, echoed by the Canadian financial establishment, one would think that Canada had abolished the free enterprise system altogether. Much of this hype is of course overblown for bargaining purposes.

The Tokyo Round of the negotiations on the General Agreement on Trade and Tariffs has resulted in major tariff reductions. Thus about 90% of trade between the USA and Canada carries less than 5% tariff, and much of this trade encounters no tariff. One effect of this drastic lowering of the tariff wall is that in many cases a US firm may find that it can supply the Canadian market more economically from its US plants, and therefore a decision may be made to close down its Canadian subsidiary plant. It does of course also work in reverse in that it has become easier for Canadian firms to sell in the US market from a Canadian base. Protectionist trade actions by the US Congress in many cases do present difficulty for Canadian exports to the US.

A dichotomy exists in Canada as regards the foreign ownership issue. The federal government, through its National Energy Policy, F.I.R.A. and various initiatives — such as the creation of the Canada Development Corporation, has tried to strengthen Canadian ownership and control in some industries. The Province of Ontario has also taken some steps to prevent foreign takeovers. Most of the provincial governments are actively courting foreign investment as a means of creating more jobs, and worry less about the long term consequences. Predictably, there is little support for any nationalistic policies in the financial community. Most of the public feel that there is excessive foreign ownership of Canadian industry, but the majority appear to think that the situation is beyond recall.

The most serious effects of the high degree of foreign ownership are the perpetual drain on the Canadian balance of payments through management fees and dividends paid to the foreign parent companies, the loss of much of our technological sovereignty, and the difficulty in achieving a higher level of R&D (currently about 1.4% of GNP), in view of the dependent relationship of these subsidiaries.

In the final analysis, although foreign ownership may in some cases retard the natural development of firms, it does not seem to be a decisive factor. Many other countries have thrived in spite of foreign ownership (for example the U.S. itself in the 19th century) and others have failed miserably although their industry was 100% owned by nationals of the country itself. We must therefore look at subtler barriers. These we contend are the result of the six major adversary systems which characterise the Canadian Economy.

In figure 1, the five principal players on the economic scene are identified. They include:

- The Federal Government;
- Business;
- Labor;
- The Provincial Governments; and
- Universities (including independent research laboratories).

Each of these relates to the others in a series of dynamic relationships that range from mild cooperation to intense adversarial opposition. The adversarial relationships are by far the most intense and have now become the rule rather than the exception. Each of these adversarial relationships in its turn generates barriers which inhibit the development not only of high technology but of entrepreneurship itself. We will now briefly survey these barriers and their consequences.

Fig. 1 *THE MAJOR ADVERSARY-SYSTEMS CHARACTERIZING THE CANADIAN ECONOMY*

ATTITUDES OF PRINCIPAL ECONOMIC PLAYERS	— PRINCIPAL ECONOMIC PLAYERS —				
	Federal Govt.	Provincial Govt.	Business	Labour	Univer-sities
Federal Government	!	XXX	XX	X	!
Provincial Governments	XXX	XX	X	X	!!
Business	XXX	X	XX	XXX	!
Labor	XX	XX	XXX	!!	!
Universities	!	!!	!	!	!

X Mild adversary system
XX Strong adversary system
XXX Very strong adversary system

! Mild cooperative system
!! Strong cooperative system
!!! Very strong cooperative system

2.1 The Public Sector/Private Sector Adversary System

This adversary system exists insofar as there is an absence of a sense of partnership between the Public and Private Sectors. The public sector tends to alienate the private sector by giving the impression that it is inefficient and both overspends and overtaxes. Its relationship with private enterprise is often perceived as paternalistic and even punitive taking in most cases the form of restrictive regulation. At the same time, the private sector both claims it can do the job alone yet cries foul whenever the foreign competition gets too dangerous. At that point the private sector requests help from government in the form of protective tariffs or subsidies. The mutual insensitivity to the possibility of partnership generates at least four barriers to high technology growth.

1) "Punitive" Taxation

In the ill-fated 1982 Federal budget and in the Quebec government budgets of recent years an impression emerged that government was out to punish business. Even today success is heavily taxed. Failure is subsidized. In addition the fiscal system encourages smallness. Small firms have much greater tax relief than larger ones. As a firm succeeds by expanding it then progressively meets the "punishment" of heavier taxation.

The same applies for successful individuals. The high progressive taxation of individual income and the overzealous manner by which tax authorities close down tax shelters adds to a general atmosphere of disincentive. One somewhat vindictive civil servant has even referred to successful entrepreneurs as "untapped

Fig. 2 *THE PRINCIPAL BARRIERS TO HIGH TECHNOLOGY DEVELOPMENT AND THEIR CONSEQUENCE*

PRINCIPAL BARRIER	DIRECT&INDIRECT CONSEQUENCE
Public/Private Adversary System	(1) "Punitive" Taxation (2) Disincentives associated with inefficient regulation (3) Absence of Long-Term Forecasting (4) Lack of concerted action leading to inability to redeploy
Federal/Provincial Adversary System	(5) Redundant taxation&subsidy schemes (6) Redundant and often contradictory regulation (7) Federal/Provincial Development Policies at cross-purposes
Provincial/Provincial Adversary System	(8) Non-tariff trade barriers between provinces (9) Provincial Governments Procurement policies
Private/Private Business vs. Business) Adversary System	(10) Small-size, absence of economies of scale, absence of horizontal integration (11) Absence of Vertical Integration and of economies of scope (12) Incompatible Products and standards (13) Adversarial Financing system (14) Short-term planning horizons
Labor/Management	(15) Short-term views (16) Fear of unemployment (17) Resistance to innovation
University/Society Lack of	(18) Irrelevance of some university research to real problems (University snubs society) (19) Non-use of relevant university research by Industries (20) Inefficient university research policies

mines of potential tax revenues" (des gisements fiscaux). That attitude is not likely to encourage success.

2) Disincentives Associated with Inefficient Regulation

Some regulation is inevitable, especially of industries where either a natural monopoly or a high concentration of economic power is present. However present regulatory systems in Canada are highly inefficient. The principal causes of this inefficiency are a) *excessive cross regulation* where the same industry is regulated often at cross-purposes by three levels of government and b) *unintended side effects of regulation.* Under the latter heading are the distortions introduced by regulation to market efficiency and their negative consequences.

The alternative to inefficient regulation is not wholesale de-regulation which has had disastrous effects in some U.S. industries. It is intelligent and harmonized regulation with enough teeth to ensure respect of the public interest coupled with built-in restraint to continue to encourage entrepreneurial activity. The intelligent regulation requires both the concertation of federal and provincial regulators and the active cooperation of the private sector. In other words an end to the adversarial relationship is required.

3) Absence of Long-Term Forecasting

One of the strengths of the Japanese and French economies in the high technology area is the long-term forecasting often done by para-public research agencies made available to the private sector. After all, this has been one of the features of French "indicative" planning which indicates what lies ahead and invites and encourages private firms to move that way. There is no coercion involved, only the communication of probable and possible futures and an ordering of national priorities. The Japanese Plan for an Information Society and the French Nora-Minc Report in 1978, both dealing with the future of micro-electronics have provided their respective countries with a roadmap to the future.

We have nothing similar in Canada. Although organizations, such as the Science Council, the National Research Council and their various provincial counterparts conduct valuable research, the topics chosen are often spotty and partial. No national overview exists at the level of Canada. Whatever overviews exist lie in the purely economic area and tend to be short-run in orientation.

The absence of a joint long-term forecasting tradition in Canada robs the private sector of an information base with which to compete successfully both here and abroad against foreign competition.

4) Lack of Concerted Action Leading to an Inability to Redeploy our Industrial Structure

Industrial Redeployment — the organized shifting of resources from sunset to sunrise industries and the development of new processes to increase structural productivity is the name of the game in the global economy. Since this redeployment creates winners and losers, it must be accompanied by profit-sharing mechanisms and redistribution formulas to ensure that no group will be excluded from the benefits of the information economy. Only a concerted public sector/private sector approach can conceptualize and implement that redeployment. With an adversarial system, the losers have too much to lose in the redeployment and, therefore, will block it indefinitely.

2.2 The Federal/Provincial Adversary System

In addition to the Public/Private antagonism an even greater adversary system exists within the public sector. In Canada the public sector is made up of eleven quasi-sovereign governments, with overlapping jurisdictions and intense competition. In particular, the Federal/Provincial antagonism is very visible and regularly occupies the headlines, especially on the occasion of Federal/Provincial Conferences.

The Federal/Provincial adversary system generates at least three barriers to entrepreneurship.

5) Redundant Taxation and Subsidy Schemes

The maze of federal, provincial and municipal taxation and subsidy schemes add up to an immense disincentive. There is double, if not triple, taxation in some cases and the cross-subsidies between federal and provincial schemes often cancel each other out, as each level of government competes to surpass the other.

6) Redundant and Often Contradictory Regulation

The multi-level regulatory muddle, especially in a field like telecommunications, creates extreme distortions and inefficiencies since quite often one regulation contradicts another one. This point is eloquently demonstrated in the CNCP Telecommunication 1983 public brief entitled "Crisis in the Canadian Telecommunication Industry." Once again the adversarial system stymies initiative.

7) Federal/Provincial Development Policies at Cross Purposes

Not only is there lack of concertation on regulation and taxation but on development objectives themselves. There are dozens of instances where the lack of Federal/Provincial concertation has, in effect, killed what would otherwise have been a very viable project. Among these instances can be mentioned, Montreal Mirabel Airport, a victim of contradictory planning objectives, some of the energy Mega-Projects, the Montreal Archipel Project, etc... In general, it must be recognized that every province cannot have a silicon valley, a biotechnology centre and an aircraft industry. Provincial specialization of function is a requirement of efficiency. Yet such specialization can only be achieved when all eleven governments subscribe to similar national development priorities which at the moment they do not.

2.3 The Provincial vs Provincial Adversary System

Complementing the Federal/Provincial antagonism is intense interprovincial rivalry which creates the following two barriers:

8) Non-Tariff Trade Barriers Between Provinces

It is no secret that Canada is not a true common market since a host of non-tariff trade barriers impede interprovincial exchanges. These barriers emanate from different fiscal systems, sales taxes, languages laws and even immigration regulations. The net result is that we tend to segment an already very small market and eliminate the possibility of economies of scale. In addition, we create disincentives to foreign investment. Foreign capital is less interested in locating in Canada when the markets are so small.

9) Provincial Government Procurement Policies

Provincial governments tend to have a buy-in-the-province procurement policy which sometimes is so intense that out-of-province firms are placed on the same footing as foreign firms. This is not an incentive for the creation of large pan-Canadian firms able to compete worldwide. Instead, local fiefdoms limit the expansion potential of the high technology firms who, very often, get their initial big push from government procurement.

2.4 The Private vs. Private Adversary System

The principal characteristic of a market economy is competition and it is therefore healthy to see firms competing with each other. However, the evolution of the global economy points to one disturbing fact: there is often a trade-off between internal and external competitiveness. In Canada, by *maximizing internal competition we minimize external competitiveness*. This situation expresses itself in the following five barriers to high technology growth:

10) Small-size of Firms Means Absence of Economies of Scale

Canada's competition laws, its anti-combines legislation and its tax policies encourage smallness and discourage bigness. While smallness is indeed beautiful and may well be desired for itself, it does not necessarily convey a competitive edge against the world giants. The absence of economies of scale, which could be achieved by horizontal integration, means that we expect our little firms to take on Japan Inc., the U.S. multinationals and the E.E.C. conglomerates. Our failure to succeed here must surprise no one. Bigness itself is no automatic advantage and excessive bigness may actually be counterproductive. However, there is a threshold of optimum competitiveness which probably lies with the medium-sized firm — not the small one.

11) Absence of Vertical Integration and Economies of Scope

While economies of scale are associated with size, economies of scope are associated with complementary production processes. Here vertical integration is a great help. When this is absent, competitiveness suffers.

12) Incompatible Products and Standards

New industries are usually led by a few pioneers. When there is no agreement between them, as to products and standards, a great confusion results with high inefficiency. In Canada, not only are these difficulties in making products and standards compatible between firms but sometimes even within the same firm, product lines are discontinued, leaving the early customers stranded with useless hardware. A case in point is AES-Data which makes it extremely difficult for customers possessing its early AES-90 word-processor to get appropriate diskettes. Further, that particular model is plagued with almost total incompatibility with all the others.

Such a situation is hardly a confidence builder since the prospective buyer of Canadian high-tech products now faces the very real possibility of being stuck with an Edsel — a discontinued loser with no software to match.

13) Adversarial Financing Procedures

Most high-tech development is done with risk capital raised either from risk-taking investors or through the banking system. The risk-taking investor tends to go abroad with his money. As to the banks, a combination of high interest rates, very conservative policies and an adversarial attitude leads to ineffective financing. The adversarial attitude comes from the lending institution desire to get its "pound of flesh" and to be harsh on repayment procedures when the business falters. In contrast, Japanese banks tend to consider themselves partners in an enterprise that they finance and allow for very easy repayment schedules. This makes risk-taking less dangerous and encourages innovation.

14) Short-Term Planning Horizons

Last, but not least, in this context is the short-term planning horizon of North American firms both Canadian and U.S. It is said that North American executives like to look into the future — but that future is only three months away. The obsession with quarterly profits means very short payback schemes. If a business cannot make it in a couple of years it is condemned.

In contrast, Japanese banks will accept short and medium-term deficits to promote long-term profitability. The results speak for themselves. Deficit operations become highly successful ventures and the Japanese move ahead industry by industry.

2.5 Labor vs. Management Adversary System

Canada has one of the top three labor-management adversary systems, challenged only by Britain and Italy in the days-lost-to-strikes department. The intense adversarial relationship manifests itself in three barriers:

15) Short-Term Views Making Long-Term Labor-Management Concertation Impossible

Business' obsession with quarterly profits is matched by organized Labor's tendency not to look beyond the next collective agreement. The result is that structural issues and the kind of joint redeployment pioneered in Austria's tripartite Concertation are forgone.

16) Fear of Unemployment

The very real and legitimate fear of unemployment due to automation leads organized Canadian Labor to resist innovation. In contrast, the permanent employment practices in Japan, faithfully implemented in North America by a giant such as IBM, creates the favourable climate within which the participation of Labor in promoting high technology becomes possible.

17) Technophobia and Resistance to Innovation

In addition to the fear of unemployment is the human fear of the machine itself: *technophobia*. This technophobia results in slowing the rate of diffusion of innovation.

2.6 The University/Society Mutual Marginalization

The final adversary-system is the mutual marginalization in Canada between the University and Society. The University barricades itself in its ivory tower and is often content, to use Marshall McLuhan's expression, to be the "rear-view mirror". University research in many social science fields is more oriented towards survival in the tenure track than relevance. The requirements of survival in the tenure track often means publishing in scientific journals, which are largely unread and where incestuous intellectual standards require prospective authors to show evidence that they know who said what, when and where (the history of thought). Relevance is neither sought nor particularly rewarded and the typical article ends with the reformulation of the same question or a conclusion to the effect that "more research is needed."

In the physical sciences, relevance is, of course, built-in and testable but cooperation with the private sector or government is often frowned upon as unworthy of a scholar.

Society, by the same token, largely ignores the University, allowing it to exist in benign neglect. Policy-oriented government civil servants and private executives often regard academic pursuits as intellectual gardening, not realizing that a highly-trained academic could, under suitable conditions, redeploy his intellectual aptitudes in the direction of policy-research.

The resulting adversary-system results in the following three barriers to high technology development:

18) Irrelevance of a large part of University Research aided and abetted by misguided promotions criteria in the tenure track.

19) Non-use of highly-qualified university experts by Society in the high-tech field.

20) Inefficient funding policies for university research.

The grants system in University Research, since it is administered by peer-review committees of fellow academics, tends to be an appendage to University tenure-track procedures. Grants tend to be given to the same individuals and the accumulation effect tends to reinforce the intellectually incestuous nature of the Univesity reward system. Further, the division of project-evaluation committees into traditional disciplinary categories makes interdisciplinary or innovative research highly difficult to fund. As a result, often excellent ideas cannot come to fruition for lack of funding.

3. CONCLUSION: RECOMMENDATIONS FOR CHANGE

This paper has attempted to identify the principal barriers to the development of Canadian high technology firms, most of them emanating from our confrontation economy with its multiple adversary system.

The avenues for change can only be hinted at here and are developed in other GAMMA papers, available separately. In a nutshell they center around the following points:

3.1 Creation of a Concertation Economy to Replace the Confrontation Economy

Concertation is not consensus or unanimity of an identity of views on all subjects. It is what an orchestra does: each instrument plays its own music in harmonious synergy with the others to create a concert. A musical concert needs a maestro. Similarly, a concertation economy needs concertation mechanisms. Some of these can be formal and entrenched in the legal documents of the nation. But the most effective ones are likely to be informal and stem from the will to work together.

3.2 The Long-Term Potential of High Technology Must be Constantly Monitored, Forecast and Assessed

Both microelectronics and biotechnology, the two dominant technologies of the last two decades of the 20th century, must be carefully monitored, forecast and assessed. These functions should be realized by a Canada-wide National body which will provide the information base with which our high-technology firms will identify their comparative advantage and plan their future accordingly.

3.3 Identification of National Development Priorities and the Implementation of a National Development Strategy

Unless there is consensus on National development objectives, each actor will continue to function at cross-purposes with other. Once the National Ojectives are agreed upon then the concertation mechanisms must operate to implement the appropriate development strategy. With a Game Plan and a Team Approach, the tremendous opportunites of our contemporary era may be fully optimized.

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GAMMA Institute

PUBLIC OPINION AND TECHNOLOGY: CANADIANS ADJUSTING TO CHANGE

Introduction

This paper analyzes public opinion trends as they relate to technological change. The data described in the paper are provided from the *Decima Quarterly Report*, collected between Winter 1980 and Summer 1983. The *Quarterly* is a tracking study conducted jointly by Public Affairs International, Canada's largest public affairs consulting firm, and Decima Research Ltd., one of Canada's leading public issues attitudinal research firms.

In keeping with the themes to be discussed at the *Canada Tomorrow* Conference, this paper focuses on such questions as:

- — do people think technology has positive or negative effects on the economy?
- — do they believe it has positive or negative effects on the average worker?
- — how do Canadians feel about change — do they reject it or accept it?
- — what is the public's perceptions of Canada and Canadian companies in the field of technology?
- — what are governments' roles in adjusting to change?

After considering these salient trends in public opinion, readers should have a good sense of the adaptability of Canadians, and of what kinds of events cause change to be more or less traumatic for the public.

Technology and the Work Place

Since the work place is the area in which the majority of people are exposed to automation and technological change, this paper will first examine technology's perceived effect on the economy, the work force and the individual.

a) Technology in the Economy

Since the *Quarterly* began testing Canadians' perceptions of the economic benefits of technology in the economy, a consistent trend has been developing. In the winter of 1980, it was found that only 41% of the Canadian people felt that automation would benefit the economy; by the spring of 1982 a plurality (49%) had come to feel this way. This trend is continuing. Summer 1983 data show that 54% of the public now believe that automation will lead to a stronger economy (Figure 1); 40% continue to disagree.

As acceptance of the economic benefits of automation increases, the public is also gradually becoming more positive about other general benefits. Two and a half years ago, 41% believed that automation would bring lower prices for consumer goods; most (51%) did not. Now 52% believe that automation will lead to lower prices, only 44% do not.

The public has also shown a consistently growing belief that technological change leads to improvements in the quality of products. Since December 1980, when 47% of respondents accepted the view that automation would lead to such quality improvement, public opinion has evolved to the point where 60% currently foresee such improvements.

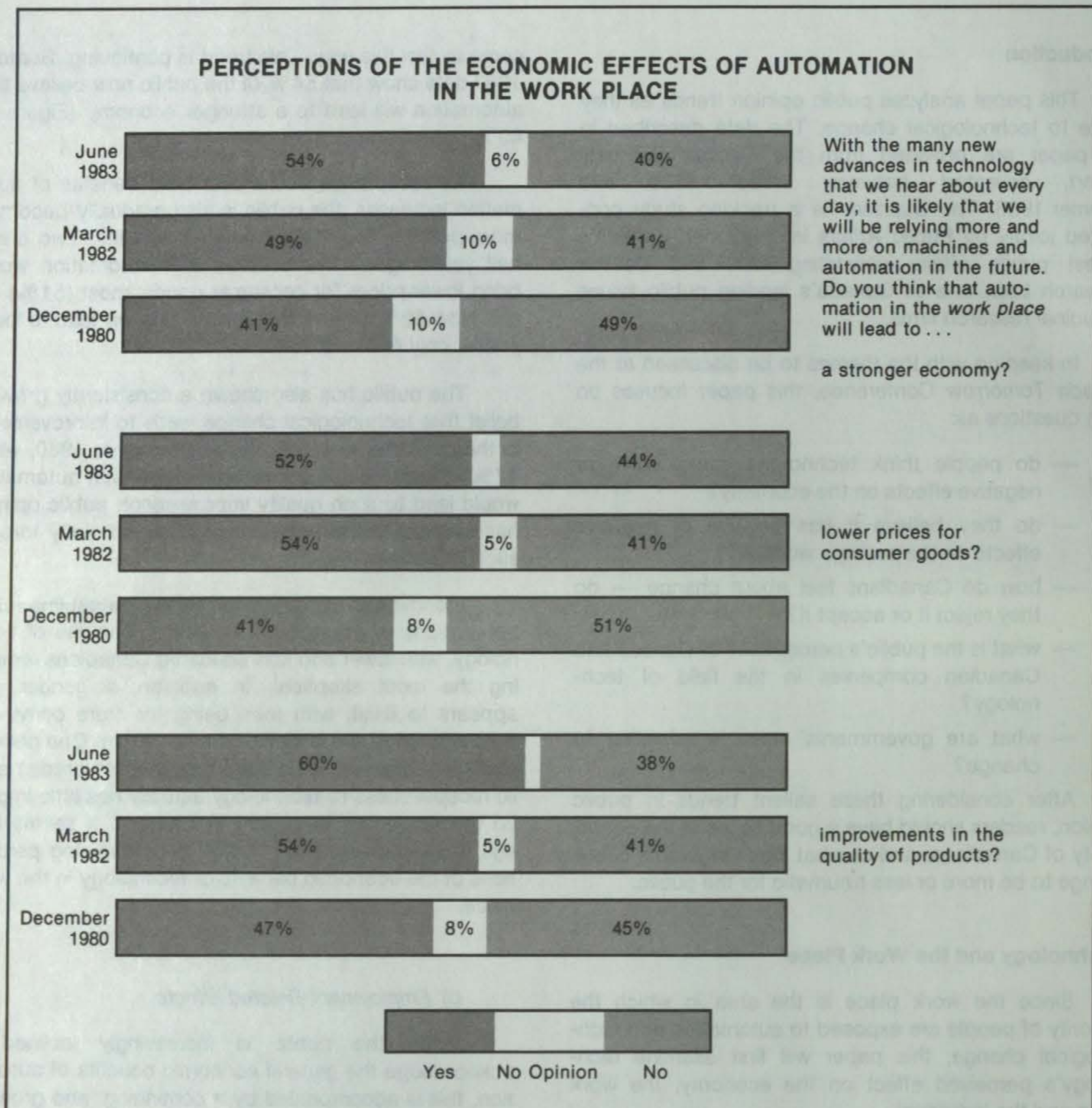
Income and education have the greatest impact on perceptions of the general economic benefits of technology, with lower and less educated Canadians remaining the most skeptical. In addition, a gender gap appears to exist, with men being far more convinced than women of the benefits of automation. One characteristic — age — that is often presumed to predict public receptiveness to technology actually has little impact on the responses described in Figure 1. It seems that age is a relatively weak factor in determining perceptions of the economic benefits of technology in the work place.

b) Employment-Related Effects

While the public is increasingly inclined to acknowledge the general economic benefits of automation, this is accompanied by a continuing, and growing, concern about technology's effects on the work force and employment.

Since December 1980 there have been slight fluctuations in public expectations regarding automation's effects on unemployment and depersonalization of the average worker. As Figure 2 indicates, the vast majority of those tested in December 1980 felt that automation would lead to higher levels of unemployment (72%), and also felt that it would lead to depersonalization for

Figure 1



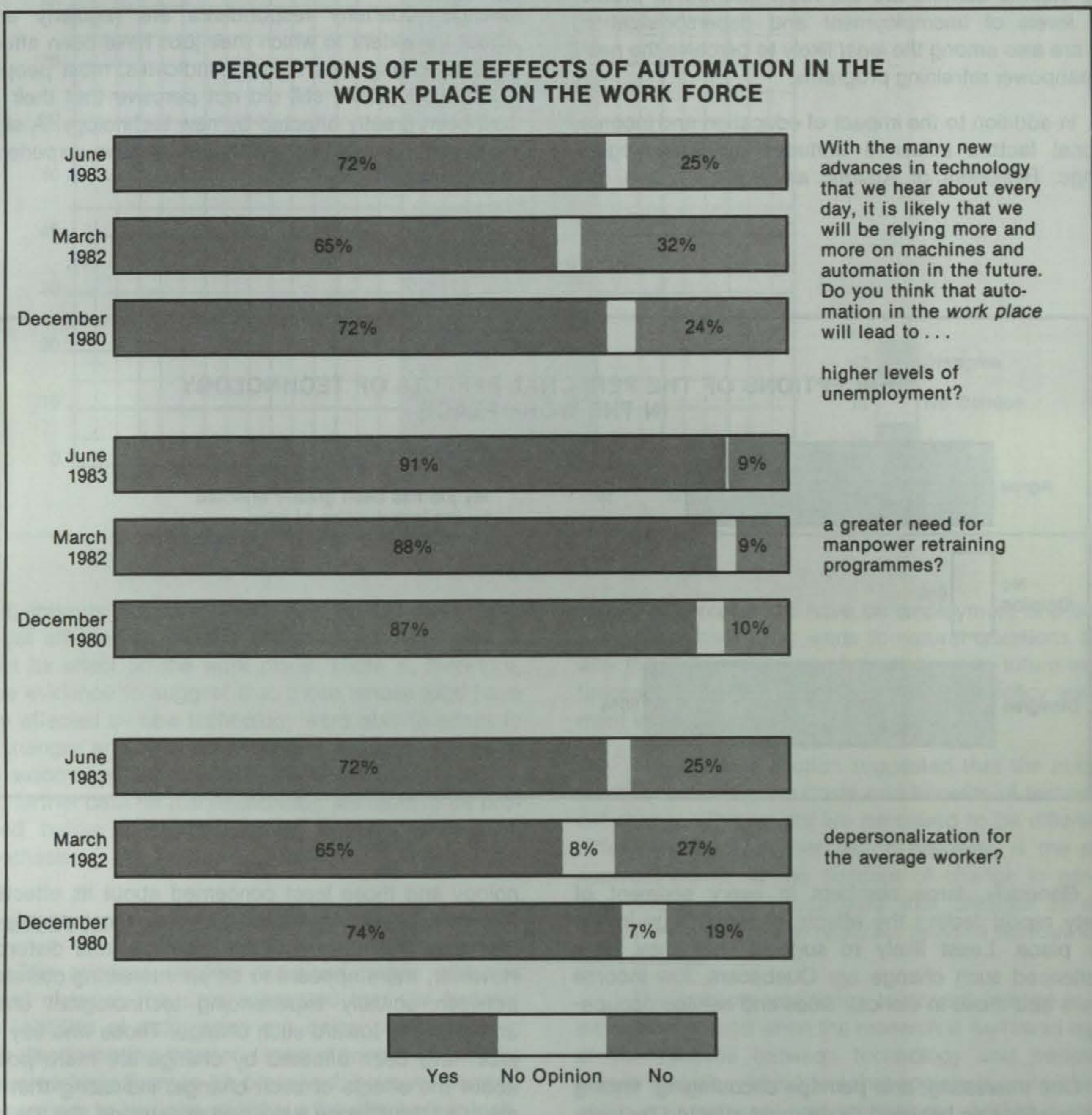
the average worker (74%). Currently, public perceptions are largely the same. This is true despite the fact that the intervening year, 1982, saw a drop in levels of concern on both of these issues. Attitudes have become more negative again.

The data provide evidence that the public is developing a more discriminating attitude about technology. While most people see benefits of new technology for the country as a whole, they remain very concerned about automation's impact on the work place.

Increase in public concern about employment issues generally (unemployment, training, security, labour-management relations) are almost certainly a contributing factor in the persistence of widespread concern about high technology's effect on the work place.

As the public's concern about the employment-related effects of automation remain high, so does the belief in the need for expanding manpower retraining programs. The data show a steadily-continuing increase in the number of people seeing this need. In fact, throughout the *Quarterly's* research, "training" has emerged as one of the most sensitive topics among the Canadian public. Over two-thirds believe that they personally could profit from such training. Technology and automation questions strengthen this attitude further,

Figure 2



with 87% saying two years ago that technological change produces a greater need for manpower training programs. A virtually-unanimous 91% say so now. Clearly, the public is not only conscious of possible negative consequences of change in the work place, but sees a great need for policies and programs that will allow people to cope with such change.

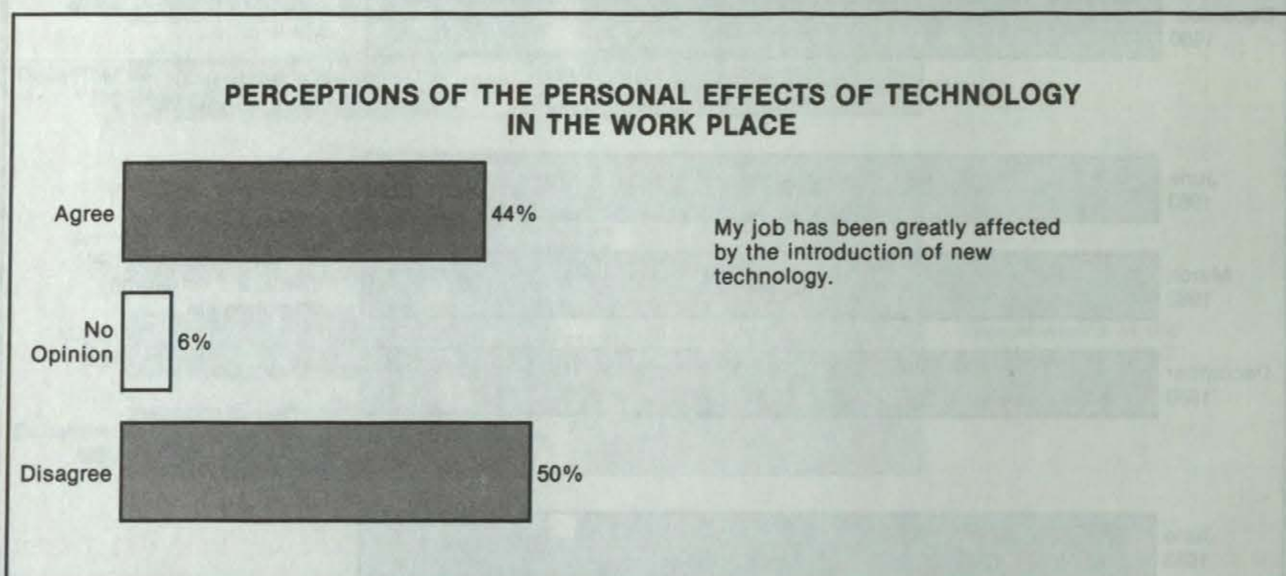
Income and education once again emerge as the factors most strongly influencing public perceptions. Interestingly, however, while the less-educated and lower-income earners are the *most* inclined to predict high levels of unemployment and depersonalization, they are also among the *least* likely to perceive the need for manpower retraining programs.

In addition to the impact of education and income, regional factors influence attitudes on technological change. Residents of Atlantic and rural Canada, the unemployed and women are more inclined to view higher unemployment and job depersonalization as effects of automation. Here again, though, age has little impact on perceptions, except that the perceived need for manpower retraining does increase with age (or, as one is further and further out of school).

c) Technology and Individual Experience

In order to assess the extent to which working Canadians feel personally involved in technological change, *Quarterly* respondents are regularly asked about the extent to which their jobs have been affected by such change. As Figure 3 indicates, most people in June 1983 (50%) still did not perceive that their jobs had been greatly affected by new technology. A significant minority (44%) say that they have experienced such change.

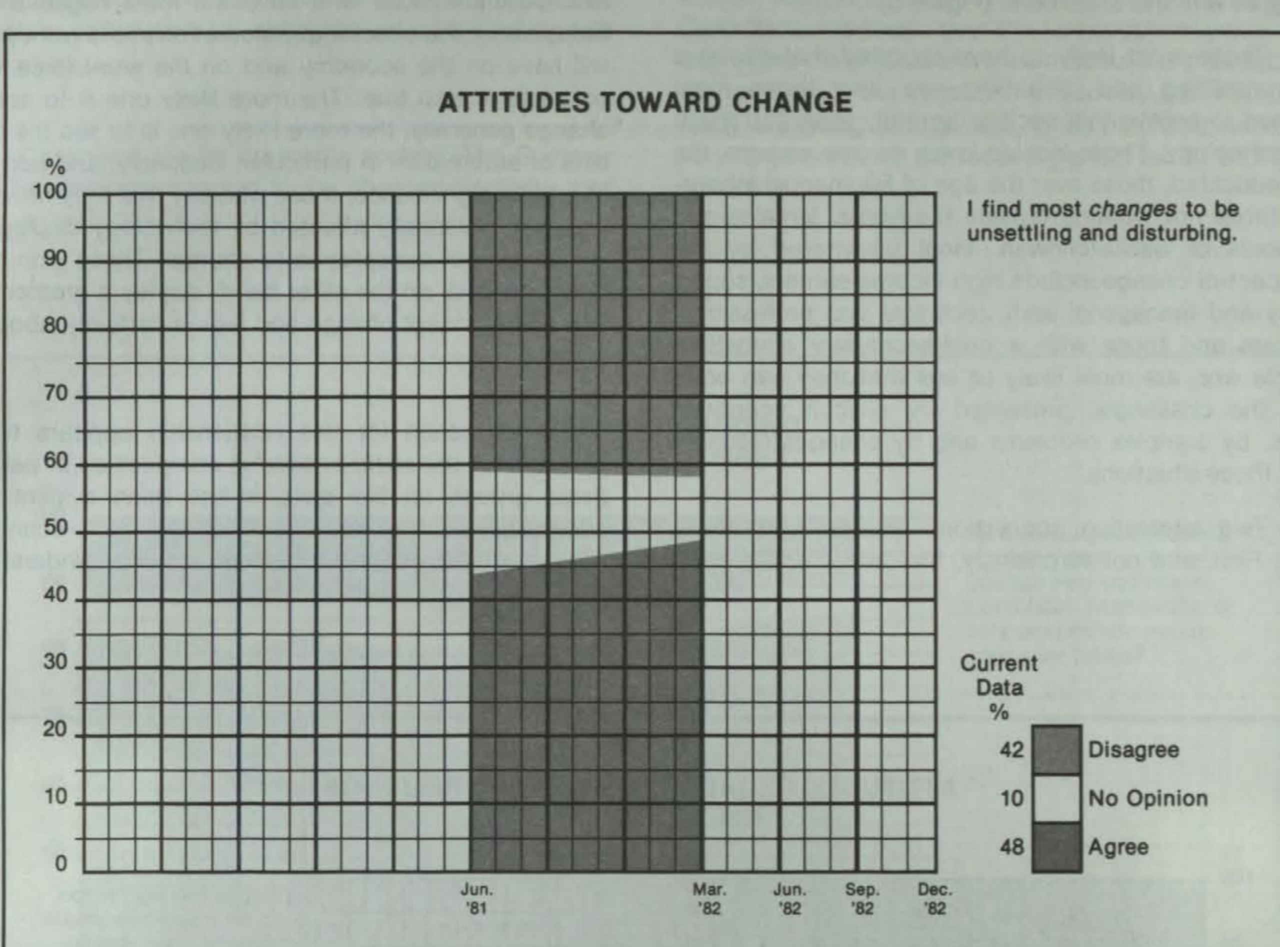
Figure 3



Generally, large numbers in every segment of society report feeling the effects of technology in the work place. Least likely to suggest that they have experienced such change are Quebecers, low income earners and those in clerical, sales and service occupations.

One interesting, and perhaps encouraging, finding is the relationship between those most affected by technology and those least concerned about its effects on the work place. As Figure 4 shows, most people say that they find change to be unsettling and disturbing. However, there appears to be an interesting correlation between actually experiencing technological change and attitudes toward such change. Those who say their jobs have been affected by change are more positive about the effects of such change, indicating that they may find the change a positive experience. On the other

Figure 4



hand, there is not as much correlation between those not yet affected by change and those most concerned about its effect on the work place. There is, therefore, some evidence to suggest that those whose jobs have been affected by new technology were able to adapt to the changes and, as a consequence, are less inclined to see automation as having negative effects. Nevertheless, further data on this relationship will have to be produced before it can be called anything more than hypothesis.

Attitudes Towards Technology and Change

The previous section examined public attitudes toward change. The data suggested that the benefits and liabilities of automation are being perceived in a more discriminating manner. General economic benefits are increasingly likely to be perceived; however Canadians continue to be unhappy about the effects that technology is perceived to have on employment and on the work place itself. This leads to natural questions about why this is so, what impact it will have on future expectations, and hence, upon the public and policy environment which is developing.

The previous section suggested that the public is carefully watching the costs and benefits of technological change. The results are perceived to be different in different areas. Another factor, however, is the philosophical barrier to the concept of change in general. The public, while recognizing that changes in many Canadian practices are required, remains nervous about such change.

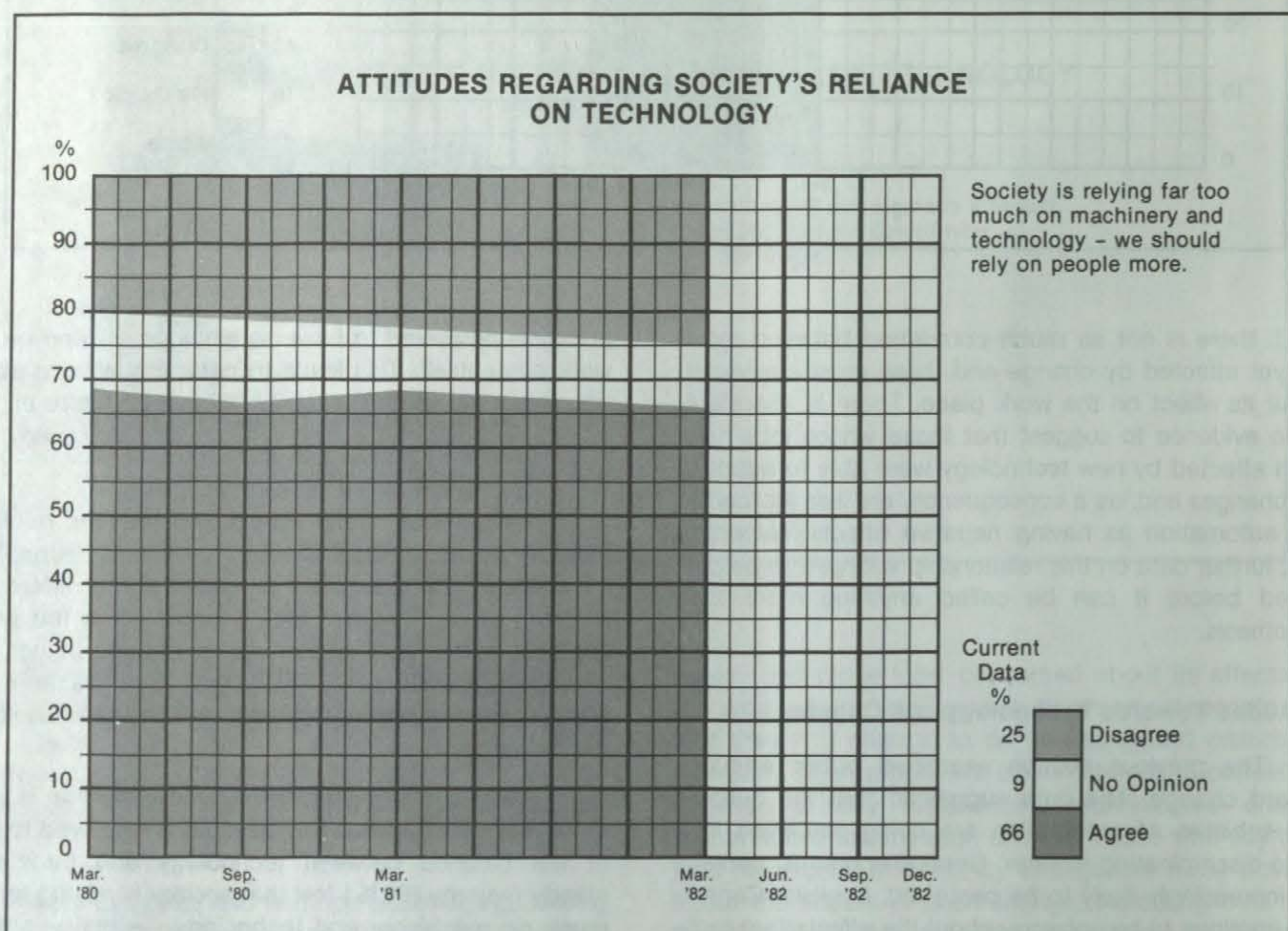
The public's reluctance to accept change is even more pronounced when the research is narrowed to look at the balance between technology and people. A steady majority (66%) feel that society is relying far too much on machinery and technology — that a greater reliance on people should be developed. Only 25% disagree with this statement. (Figure 5)

Those most likely to have reported that changes are unsettling and disturbing are also those most inclined to believe that society currently relies too much on technology. These include lower income earners, the less educated, those over the age of 50, manual labourers, those not working outside the home, females and residents of Saskatchewan. Most undettered by the prospect of change include high income earners, supervisory and managerial staff, technical and professional workers and those with a post-secondary education: people who are most likely to feel that they can cope with the challenges presented by difficult economic times, by complex problems and by changes resulting from those situations.

Two interesting conclusions emerge from these data. First, and not surprisingly, the demographic characteristics that describe those least accepting of change also describe those who have the most negative attitudes about the effect that automation in the work place will have on the economy and on the work force. The converse is also true. The more likely one is to accept change generally, the more likely one is to see the benefits of automation in particular. Secondly, and perhaps of greater significance, those who say that they have not yet been personally affected by technology display the lowest level of acceptance to change. Those who have been affected, on the other hand, display a greater willingness to accept change and less uncertainty about its effects.

The reason for this relationship appears to be grounded in the socio-economic composition of each of these groups. In the past, it has been evident that individuals on the higher end of the socio-economic scale are most inclined to believe they can understand,

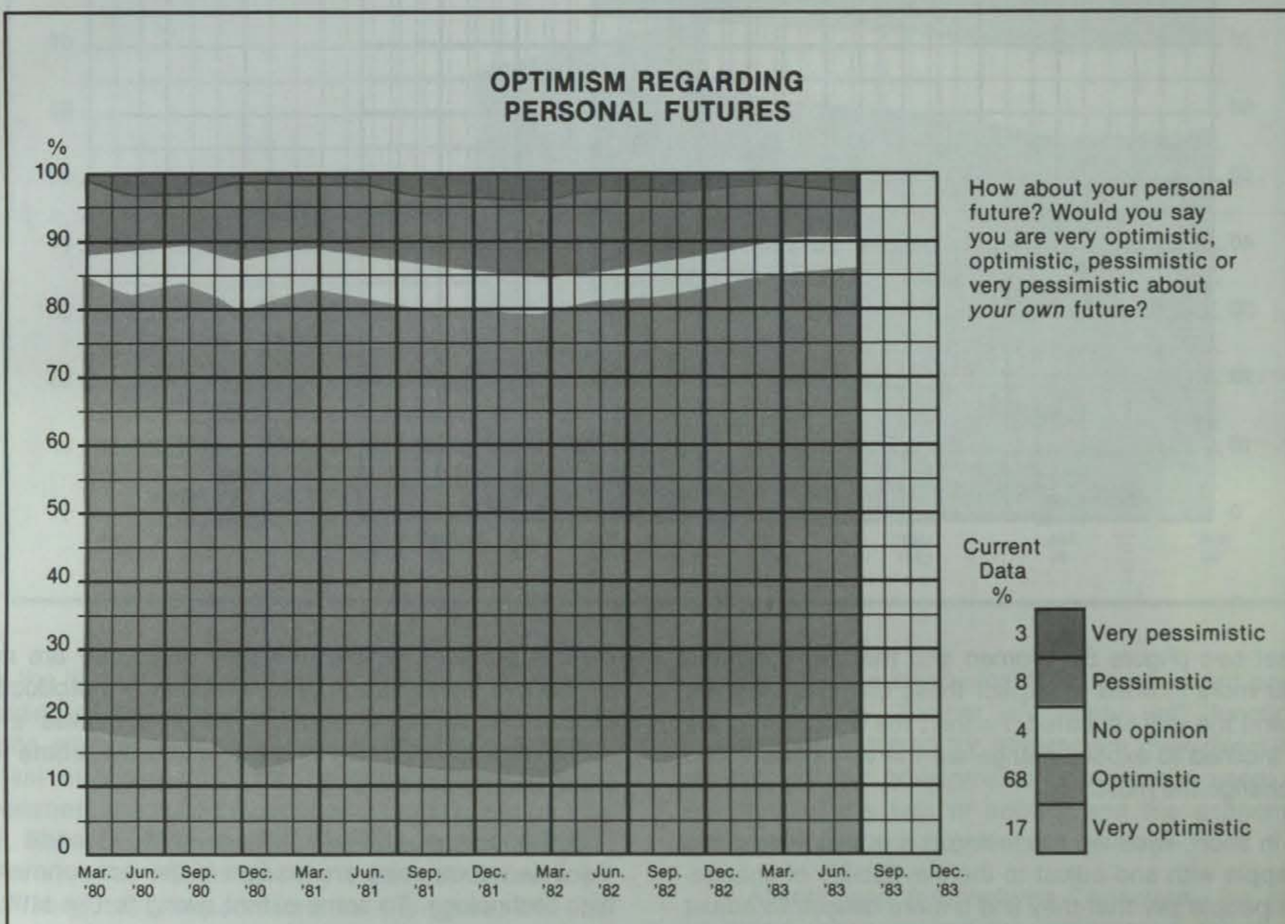
Figure 5



and even influence, change. Personal security and a sense of personal efficacy have an important impact on people's self-described ability to accept and benefit from change.

Canadians are an optimistic society. The Summer and Fall findings reported in the *Quarterly* indicate that optimism regarding personal futures is high (Figure 6); indeed, as high as they have been at any time. However, Canadians, especially over the last couple of years, have expressed considerable concern about the present; they do not, even in the midst of the recovery, feel that things really are going all that well. Unemployment remains a very large concern, the recovery is not felt to be helping solve this problem.

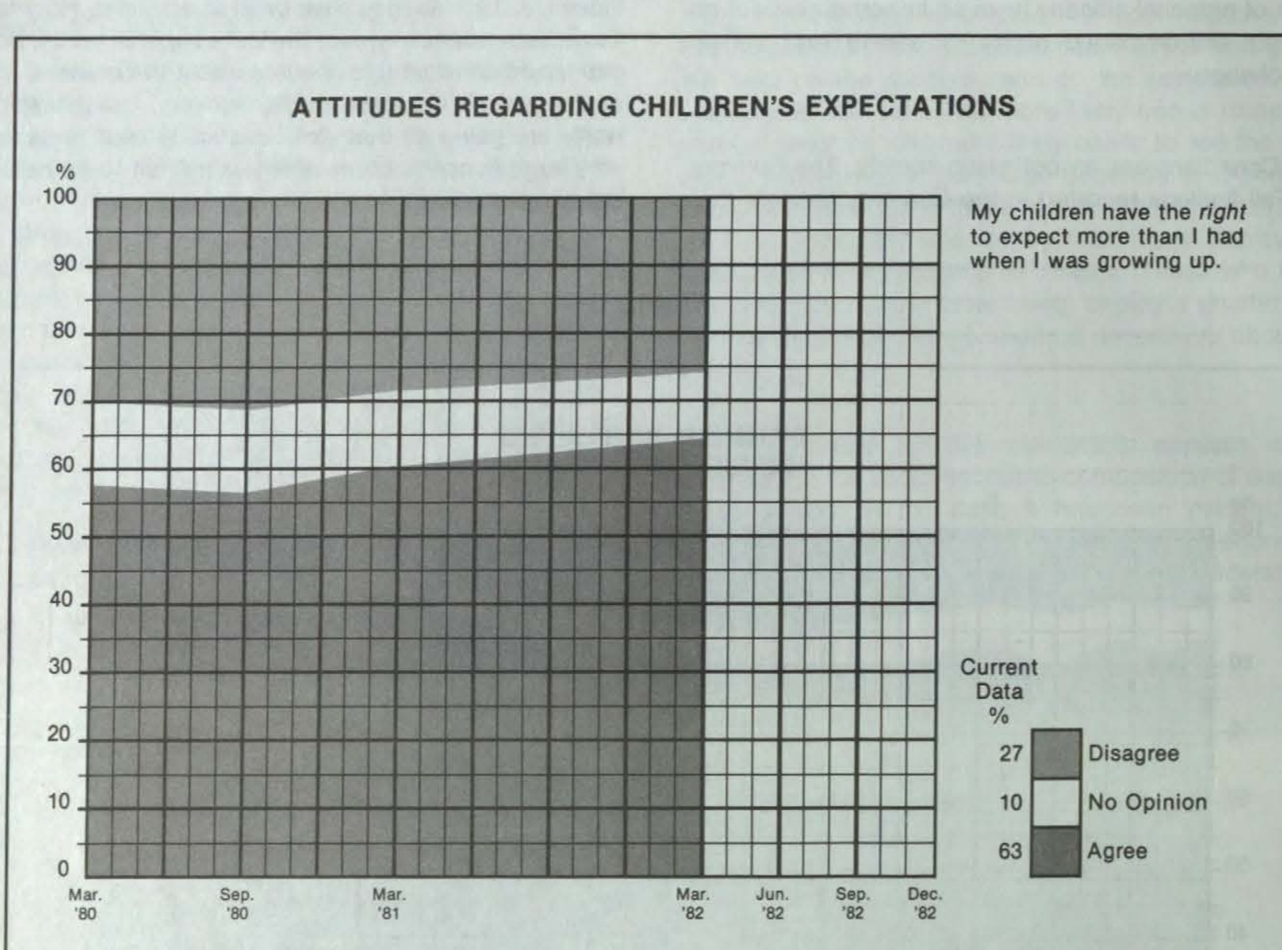
Figure 6



The seemingly conflicting attitudes about the future and the present (optimism vs concern) imply an acceptance, even a demand, for change. The fact that the public accepts, as inevitable, future progress is borne out by the steady, even growing, conviction that the next generation *has a right* to expect more than did the present generation. As Figure 7 shows, 66% believe their children can expect more, with only 27% disagreeing. Interestingly, it is those people who find it most difficult to accept change in their own lives who are most likely to say their children can expect better futures.

Not only does the public recognize, (if begrudgingly) that change is necessary, but the data indicate that people expect the rate of change in the future to escalate. A full 74% of Canadians believe in the inevitability of change — that in fact, Canadian society will experience more change in the next two years than in

Figure 7



the last two (Figure 8). Women and the less educated are far more inclined to expect these changes than are men and the well educated. Further, the people who are most inclined to expect change are the very people who fear change the most.

In short, what we are facing is a public attempting to grapple with and adjust to the inevitability of change. Some people say that they find it more difficult to adjust to change than others, even as they recognize that change is inevitable. Attitudes are further torn by the feeling that technological advances are necessary, and, to a lesser extent, desirable. The benefits are weakly established; the negatives clearly so, in the minds of many Canadians.

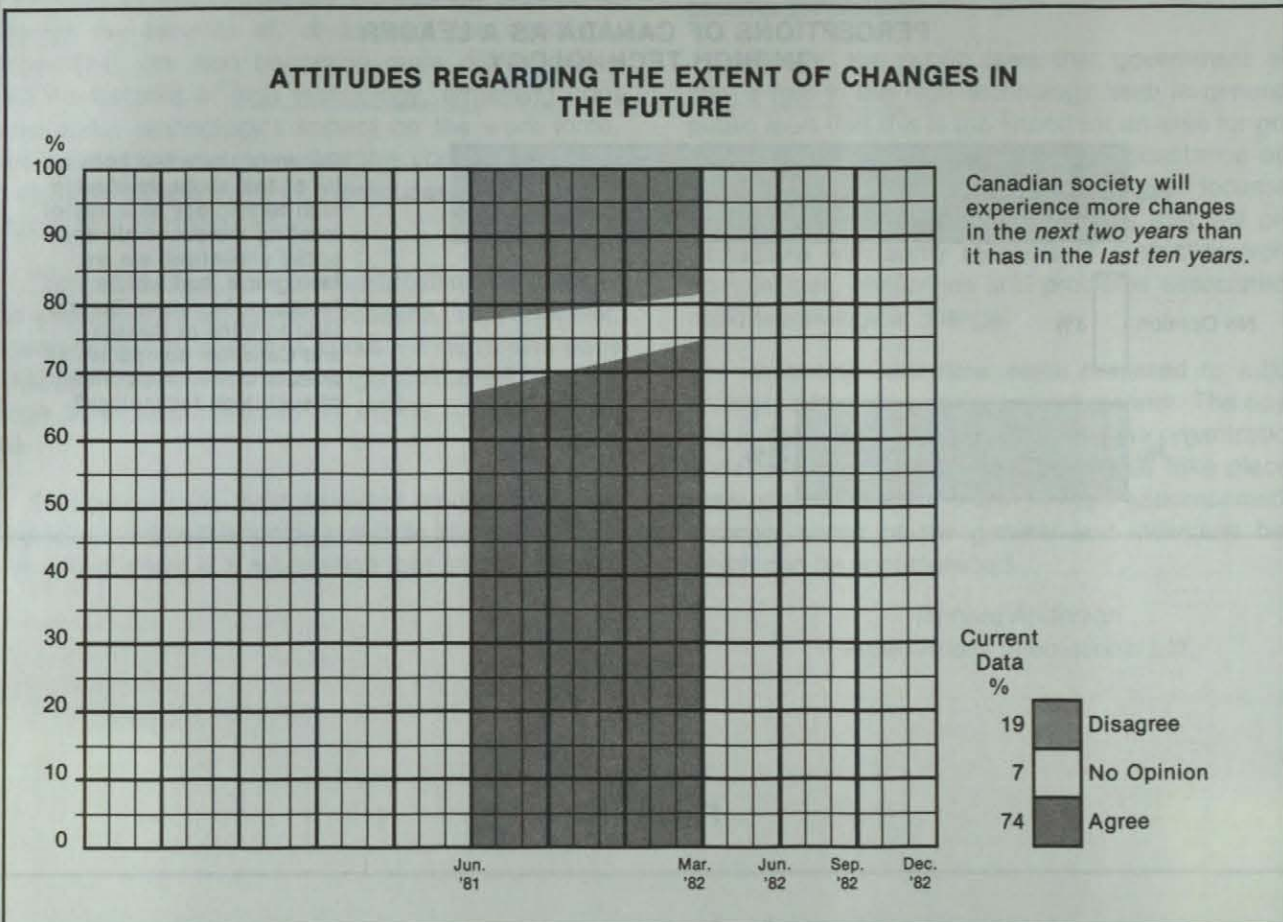
Canada and High Technology

Canadians believe that Canada has a productivity problem — that the country is not competitive with many of its foreign competitors. People tend to externalize this problem, saying that they personally are more productive than average; that the country's productivity problem is someone else's. (This also implies a low sense of personal threat in the productivity debate — it is focussed on "others".)

Canadians (66%) believe that Canada and Canadian companies are leaders in the development of high technology. To some extent owing to this attitude, the bulk of the population does not believe that companies involved in high technology need any greater level of assistance from government than do other industries. As Figure 10 indicates, Canadians are generally content with the amount of government assistance that they perceive high technology firms now receive.

The public seems less certain about the amount of control governments have over the high technology industry. When asked whether they favour or oppose greater government control over that industry, 52% say they do favour greater control (while 42% favoured

Figure 8



less), the highest number of any of the industrial sectors (including oil and gas, mining and banking) mentioned. Despite emerging public opinion trends opposing government intervention in the economy, these findings demonstrate the public's continuing pragmatism on this topic. Government involvement in the economy, particularly in a sector viewed as "key", can still attract support. The public's expectations for the future, and the description of current problems, suggest that the high technology sector may be seen as one of these key sectors. There are two reasons for this: the problem-solving (competitiveness and productivity) aspects of technology, and the problem-creating aspects, namely unemployment, rapid change and depersonalization.

Other *Quarterly* data suggest that Canadians have developed, over the last couple of years, a fairly broad antipathy to increasing government intervention, especially direct ownership. However, some sectors are more affected by this than are others: where problems or opportunities are clearly identified, pragmatism prevails over philosophy. Further, a "safety net" function is increasingly preferred for government over direct intervention, wherein governments help those in need, leaving most of the rest of society and the economy to individual, private sector decision-making.

Atlantic and francophone Canadians, the poorly educated, labourers and the unemployed are all more likely than the average respondent to favour greater government control over the high tech sector. These are, generally, the same people who are most concerned with technological change. Supervisory and managerial staff and high income earners are among those least in favour of further government control. These are, generally, the people least concerned about technological change. Here, again, a "class" of socio-economic distinction between the two groups is evident, a disturbing fact, perhaps, in a country not traditionally marked by such differences.

Figure 9

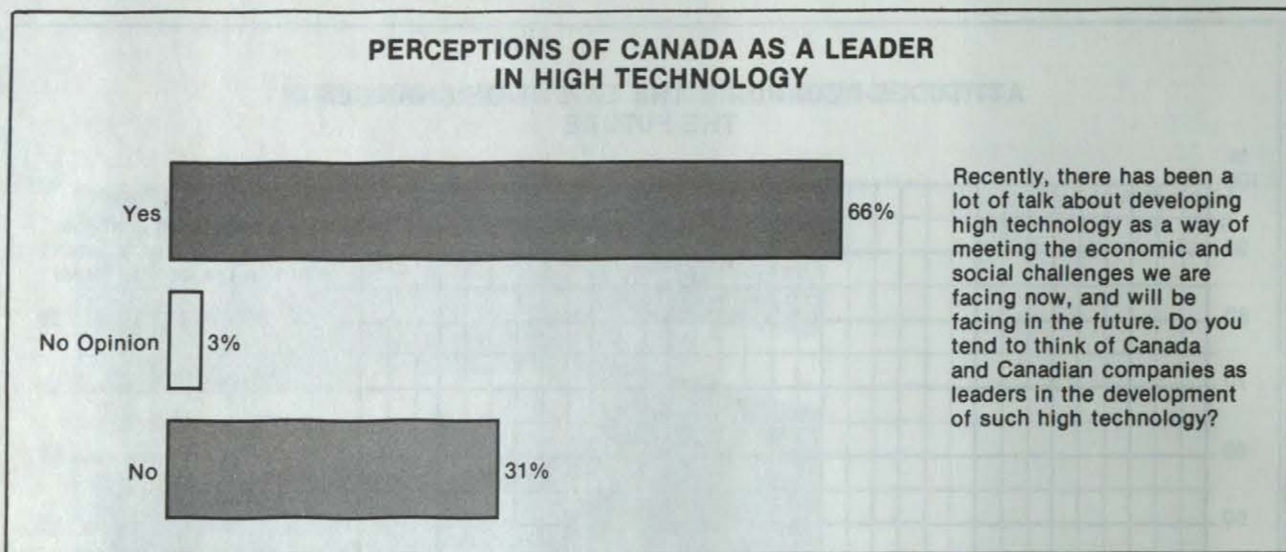
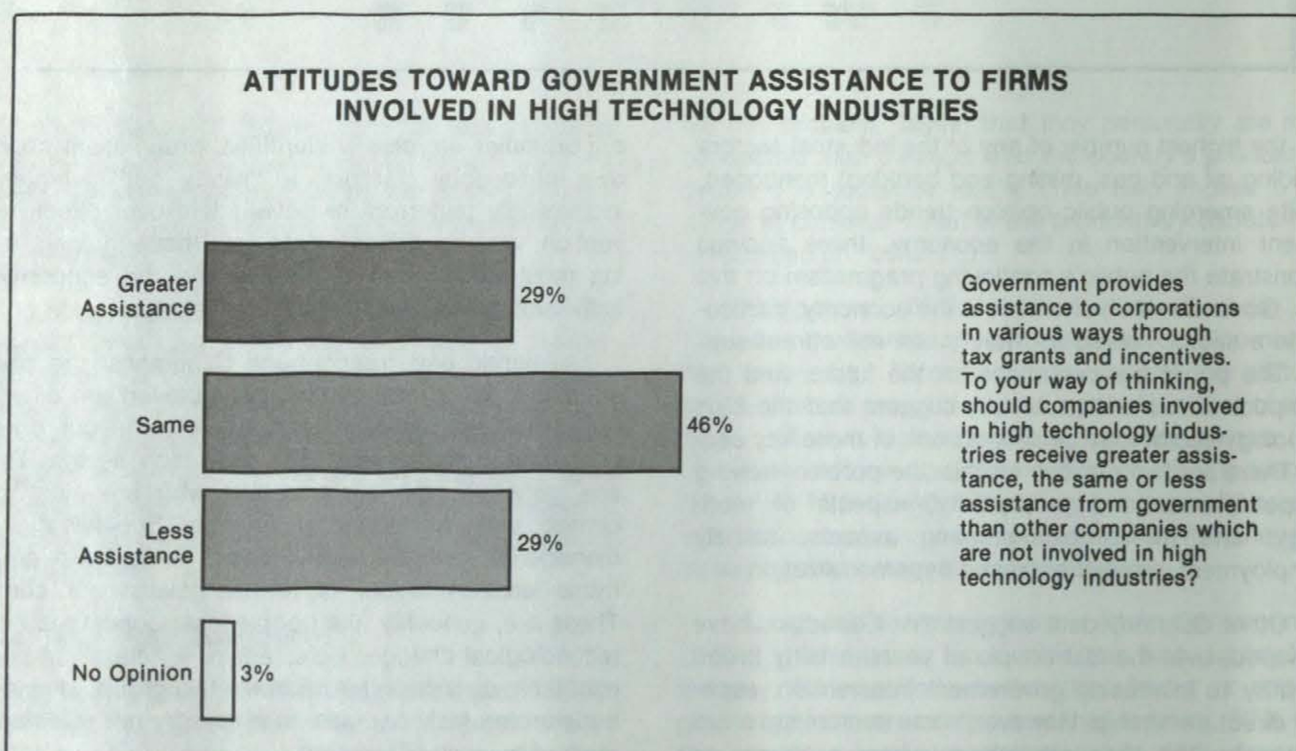


Figure 10



Conclusion

It appears that people are increasingly inclined to recognize the benefits of, or at least the need for, change. They are also becoming more discriminating about the benefits of high technology, remaining concerned about technology's impact on the work force. There is also some evidence that this concern becomes less acute as people come into direct contact with technology in their occupations.

The public does have a predisposition for change, given the country's economic problems. This, however, is accompanied by concerns about the types and pace of change. There is also a strongly-perceived need for change to be accompanied by efforts to help people cope.

This tendency is most prevalent among individuals on the lower end of the socio-economic ladder. Yet even in this group, there is a recognition that change is inevitable, and in fact necessary, to achieve the kind of future that all believe possible for the country and succeeding generations.

Finally, the public feels that government should play a role in the high technology field. In general, the public feels that this is too important an area for governments *not* to remain involved. The acceptance of government involvement appears to be most focussed on supportive and educational functions that will provide Canadians with some measure of protection from the complexities, challenges and problems associated with rapid technological change.

In short, Canadians seem prepared to adjust to change, if in a slow and skeptical manner. The opportunity is there for government and private organizations to undertake adjustments, provided these take place in a reassuring fashion, and are perhaps accompanied by a stronger sense of the general and individual benefits which can be accomplished.

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INSTITUTIONAL BARRIERS TO TECHNOLOGICAL CHANGE

Introduction

The subject of institutional barriers to technological change involves vast and complex issues. This essay approaches these issues in very broad terms. As a background to this discussion, it includes some brief comments on: underlying concepts; knowledge, science and technology; and attitudes to institutional and technological change. It then selectively focusses on some institutional perspectives — international, government, business, labour, educational and financial.

Some Underlying Concepts

Man's mind has an almost infinite capacity to create institutions. These are often intended to be vehicles or conduits for change. But they are also often intended to achieve or maintain stability and order, if not a *status quo*. Moreover, institutional organizations, especially if they are established as, or grow into, sizeable concentrations of people, tend to be hierarchical and bureaucratic, creating an environment in which initiatives for change become dulled and ineffective unless they receive powerful encouragement from within, or experience powerful external pressures. They also tend to develop their own "cultures" which either explicitly, or implicitly and sometimes almost imperceptibly, develop inflexibilities that are inimical to change. Thus, even in institutions that have broad terms of reference, the mere definition and periodic redefinition of objectives and "missions" — let alone effective initiation and management of change — is inherently difficult.

New technology, on the other hand, compels change. Its application is akin to biological processes. It can survive only in an environment in which there is death as well as new life. It creates, but it also destroys. New technology is interpreted here to have a very broad meaning, encompassing such far-reaching revolutionary changes as the invention of deposit banking or oral contraceptives, as well as miniscule steps made in the latest technical gadgetry. In this broad perspective, institutional change and technological change can, of course, sometimes be viewed as being synonymous: for example, the establishment of parliamentary democracy may be perceived as a major institutional change, or as a major change in the "technology of governance". Such an example also illustrates the birth and death process — the creation of a wider base of power among the citizenry and the destruction of monarchical powers.

Because new technology compels change, it has, in multitudinous different ways, been feared or welcomed, obstructed or vibrantly pursued. Man — at least, at his best — has a powerful innate curiosity for the new and different, a curiosity that can be visionary or morbid. But man — even at his best — also has an innate aversion to the new and different, because of the insecurities and risks involved. The development of knowledge, science and technology inherently concerns the new and different.

Knowledge, Science and Technology

New thoughts and visions about institutional arrangements, as well as mental efforts to gain new understanding about ourselves and our universe, have provided a stunning historical record of the creative genius of the mind of man. But visions and discoveries are very different matters from innovative implementation of new ideas and knowledge. Basic research, for example, has been defined by the U.S. National Academy of Sciences as "research with no application in view". Technological change, by contrast, is a process of practical applications of both new and existing ideas and knowledge.

Historically, there have been times — indeed, some have argued that most of human history has consisted of such times — when even existing, let alone new, knowledge was considered to be too dangerous to be generally disseminated or transferred.

Instead, it was monopolized and tightly restricted to the care of small groups of elites, either religious or secular. In some situations, this reflected basic mistrust of knowledge and science *per se*. In others, it undoubtedly reflected conservation of information deemed to be too dangerous to set loose because of potential threats to the existing power structures or to social stability.

Technological change has historically been the subject of greater and more widespread reservations and constraints. These have ranged from outright suppression, to discouragement and deliberate frustration of effort, to narrow professionalisms and specializations seeking to deter encroachment into areas of particular interests and claimed expertise.

The Importance of Attitudes

Fundamental to the scope and nature of technological change are human attitudes. The Middle Ages in Europe represented a time of little change. It was characterized by a system of structural rigidities, high degrees of dependence among individuals and groups, and an environment that was infertile for the development and use of new knowledge because it might pervert things already known and be upsetting to institutions already solidly and stolidly in place. The pervasive attitudes in the institutions of power were antipathetic to the concept of "progress".

Contrast this with the situation a century ago. To be sure, by today's standards, the pace of man's scientific, technological and economic progress was relatively slow and simple in the nineteenth century. But, at important points and in key ways, attitudes were different, and had become more hopeful and optimistic about economic and social progress through the development and use of new technology. These latter views have generally prevailed among today's more industrially advanced countries. Moreover, powerful stimulus has been given to the development, deployment and diffusion of new technology, with transportation and communication revolutions that have shrunk man's world in conditions of enormously increased mobility of people, goods, services, money and knowledge. The chief difference between today and previous periods of man's history is the present scope, complexity and swiftness of scientific and technological change, and the far-reaching impacts on virtually all aspects of human life.

Basic attitudes are still poised positively towards technological change. The pervasiveness of this is illustrated by: government measures to promote larger R&D activities and the growth of new high technology industries; business initiatives to develop and apply new process and new product technologies; and consumer attractions to new and more technologically sophisticated goods and services.

Yet, concerns and uncertainties, both current and potential, about adverse impacts of new science and technology are also widely prevalent today. There are many dimensions to these. Two sets are perhaps of special note. One set arises from the previously mentioned fact that technology compels change, and that such change frequently tends to destroy jobs, bankrupt business firms, undermine skills and experience, and generate instabilities. The other set arises from the threats that new technologies may pose both to human life and to the institutions created to preserve and enhance a society's welfare.

Thus, today, there are many elements of ambivalence about technological change. This ambivalence does not appear so much to reflect any deep or widespread mistrust of science and technology, as a concern about basic human nature. Such concerns have increasingly come to be enshrined in social actions and institutions, in legislation and regulations. These focus on appropriate social and technological change, as well as equitable assistance to individuals and entities experiencing adverse impacts from it.

Institutions

Today's world is a vast institutional maze. Canada is involved in many international organizations and institutional arrangements. Domestically, the institutional maze encompasses federal, provincial and municipal governments, business and labour organizations, agricultural bodies, educational and health care systems, legal and other professional and technical groups, the judicial and penal systems, financial institutions, cultural, recreational and charitable entities of many types, such "old pillars" as the family, the community and religious institutions, etc. etc. In varying degrees and in various ways, all of these are affected by (or themselves affect) technological change since it is such a permeating feature of our society.

Obviously, within the confines of a paper of this nature, it is impossible to consider more than a few selected aspects of institutional barriers to technological change. The following discussion therefore focuses on only six areas — international, governments, business firms, labour organizations, and educational and financial institutions. Also, to provide a more manageable basis for such a review, the meaning of technological change will essentially be narrowed to the area of industrial and closely related technologies.

International Perspectives

Intergovernmental relations have evolved in remarkably complex ways since the end of the Second World War; so have relationships among and between private organizations, and between the latter and governments.

In the early period after the War, the basic thrust of the international policies of the major industrialized nations was to create conditions and institutions that would preserve peace and promote prosperity. The strategic approach to the achievement of these goals was built centrally on the concept of developing a more open international environment, with appropriate institutions to foster such openness. Key objectives were: freer trade, currency convertibility, less restricted capital flows, better policy harmonization — and all of these within frameworks intended to maintain rules that would promote more orderly and less uncertain world economic progress.

For a considerable time, unexpectedly high degrees of success were achieved in the pursuit of these objectives. Inevitably, many of the institutions became involved — some of them very deeply involved — in scientific and technological matters, spanning such diverse fields as agriculture, engineering, atomic energy, communications, transportation, medicine, environmental protection and ocean activities. On the whole, they have unquestionably helped to spur and diffuse technological change on a wide international scale.

This more open world economic and financial environment also created highly favourable conditions for massively increased industrial technological changes and transfers, especially through the rapid growth and spread of multinational corporations. The latter, along with effective technological intelligence systems, appears to have been the most dynamic and cost-effective vehicles for achieving international technology transfers; recent studies have concluded that licensing and joint venturing have been less successful.

In the international field, however, new emphases have emerged during the past 10 or 15 years. Many of these have their roots in sharpened senses of "sovereignty". They include: less open conditions for multinational investment; more narrowly focussed efforts to promote national technological sovereignties; and concerns about excessively cheap foreign sales of industrial technology or inadequate vigilance to prevent industrial technological espionage.

Yet, the risks of serious national compartmentalization would not appear to be great. Under conditions of rapid and complex technological change on a world scale, the direction of basic movement will inexorably be towards "internationalization". This is particularly so of the so-called high technology industries. Among these, are many which are still in the early stages of their growth cycles, and upon whose future, Canada's prosperity may heavily depend.

Government Perspectives

Technological change is clearly a subject which generates mixed feelings in government. On the one hand, governments — and Canadian governments recently have provided good illustrations — seek to encourage and promote "scientific and technological progress" for example, by establishing monopoly patent rights to inventors, by providing special incentives for R &D, by extensive research grants, by allocating substantial resources to technological research within government departments and agencies, by funding technology centers, and by maintaining intelligence networks abroad to monitor new technology and to direct relevant knowledge to appropriate points in the domestic arena.

On the other hand, governments also have great concerns about technological change and may seek to attempt to obstruct it. Although the following quotation is long, it is worth recalling in full, because of its aptness in this context. On January 1, 1829, Martin Van Buren, Governor of the State of New York, and a subsequent President of the United States, wrote the following letter to Andrew Jackson who was then President.

> "To: President Andrew Jackson
>
> The canal system of this country is being threatened by the spread of a new form of transportation known as "railroads".
>
> The federal government must preserve the canals for the following reasons.
>
> ONE — If canal boats are supplanted by "railroads" serious unemployment will result. Captains, cooks, drivers, hostlers, repairmen and lock tenders will be left without means of livelihood, not to mention the numerous farmers now employed in growing hay for horses.
>
> TWO — Boat builders would suffer and towline, whip and harness makers would be left destitute.
>
> THREE — Canal boats are absolutely essential to the defense of the United States. In the event of expected trouble with England, the Erie Canal would be the only means by which we could ever move the supplies so vital to waging modern war.
>
> For the above reasons the government should create an Interstate Commerce Commission to protect the American people from the evil of "railroads" and to preserve the canals for posterity.

As you may well know, Mr. President, "railroad" carriages are pulled at the enormous speed of 15 miles per hour by "engines" which in addition to endangering life and limb of passengers, roar and snort their way through the countryside, setting fire to the crops, scaring the livestock and frightening women and children. The Almighty certainly never intended that people should travel at such breakneck speed.

Martin Van Buren
Governor of New York"

It is all there: the concern about unemployment; the feared dislocations to the economy; the hazards to human life; the inclusion of a "mega-argument" (national security); even an appeal to the views of a Higher Authority.

Fortunately for Canada, railroad technology forged ahead. Railroads served as a very vital element in the building of this nation.

Government barriers to technological change? Yes, there are many of them. For example, legislation and regulations provide bases that lead to complex and often slow and excessively meticulous processes for project approval and product licensing. Bureaucratic delays and red tape may frustrate timely implementation of new technology until leadership is seized by others. Canada has a relatively poor record in "staging out" promising new technology from government laboratories to successful commercial applications. Rising emphasis on the development of technological sovereignties in Canada has drawn attention away from the opportunities for cost-effective imports of technologies. Most new technology in Canada always has been, and will continue to be, drawn from outside the country. The late Senator Maurice Lamontagne, when he was Chairman of the Senate Committee on Science Policy, stated that if Canadians were highly successful, Canada could expect to account for about 3 percent of the world's total new inventions.

In addition, competing and conflicting national economic and social goals — in areas such as regional development, sectoral growth, new job creation, foreign investment and energy, to name only a few — have innumerable, kaleidoscopic adverse impacts on technological change. Moreover, in a very general way, successful technological change in Canada has been impaired by an unbalanced approach by government to the whole process of innovation. Relatively heavy focus has been placed on the early stages of invention (R&D incentives and patents), and relatively less on the later and usually more costly stages of applying new inventions successfully and diffusing these applications quickly and widely through the economy.

Yet, with the growing recognition of the key role of technological change in the pitiless world of intensifying competition, and with growing acceptance of the view that we are now globally involved in a "nova-like" technological explosion in the field of information, more encouraging and cohesive approaches to technological change by government appear to be emerging.

Business Perspectives

Business organizations represent the dynamic core of changing industrial technology. This is where most of the action is and should be. This is where outstanding management and organizational skills should be pushing forward the frontiers of new process and new product technologies, and mobilizing new capital investment and appropriate human, material, financial and other resources to make them work well. This is where technological change should be working its magic to help produce productivity gains that ensure growth, contribute to successful penetration of foreign markets, assist in countering foreign competition and adjust to changing domestic demand patterns. Such productivity gains should further help, especially over the longer run, to improve average real living standards, create more and better jobs, restrict inflationary cost increases, maintain viability in a nation's international balance of payments and generate a rising overall base of taxable national income to support a society that is both humane and committed to individual freedoms.

The stories about successful industrial innovation in Canadian business are legion. Many are stories of great accomplishments under conditions of great uncertainties, adversities and fragilities. But it is a basic trait of human nature to wish to take full credit for success and to be critical of external sources and conditions that have deterred efforts or made them only partially successful. The fact is that within business firms, too, there are frequently barriers to technological change. These come in many guises and sizes.

A few illustrations:

— organizational failures, in the sense of developing and tolerating hierarchical and bureaucratic structures that confine and dull human entrepreneurial talents and creativity in many parts of an organization;

— human resource management policies that fail to make effective use of the rising levels of education and skills of employees, and by doing so, breed apathy and alienation, and perhaps even destructive adversarial relationships in the workplace;
— inadequate bases and systems for gathering, evaluating and communicating information about new technological change, especially among competitors; as well as unexplainable slowness in applying known and proven technologies (dozens of analytical studies have demonstrated that technological diffusion is generally an extraordinarily slow process);
— lack of effective longer-term strategic R&D planning, especially in the field of new product development (to bring major new product lines to successful commercialization on a significant scale typically requires many years of development); and
— inadequate priorities to such matters as "obsolescence monitoring programs", development of more technologically-oriented management, and employee retraining systems (see below under Labour).

Such deficiencies in Canadian business firms require urgent attention as it becomes increasingly apparent that technological superiority is growing in many industries among our principal industrial trading partners.

Labour Perspectives

In recent years, labour unions have frequently been singled out specifically, and the collective bargaining processes more generally, as important barriers to technological change. They are, but the issues are often complex.

Collective agreements are vehicles that set out detailed terms of contracts, going well beyond matters of wages and many other forms of compensation and benefits. They deal with such wide-ranging issues as job content, working conditions, working hours, seniority, grievance procedures, occupational health and safety, procedures relating to strikes or lockouts, procedures about introducing technological change, retraining programs, etc. Some of them are massive, detailed documents.

The aim in such agreements is to codify specific conditions and commitments governing both the responsibilities and conduct of business management and those of union workers. In attempting to achieve this end, it is inevitable that collective agreements, typically forged and tempered in adversarial cockpits, should become instruments embodying rigidities. These can greatly complicate, slow or even preclude technological change.

Barriers to technological change typically arise not so much from the "upthrust" of compensation packages — although these may threaten job security (or a firm's survivability) as cost cutting is mandated by unforeseen competitive pressures and/or demand weaknesses. It is, rather, the inflexibilities in work rules, seniority provisions, job specifications and processes for accommodating change that give rise to problems in technological adaptations. Of course, compensation increases and the rigidities imbedded in collective bargaining agreements may work in perverse and vicious ways, especially if the commitments to "better pay" accentuate needs for faster technological change, especially labour-saving change, that cannot be readily implemented because of contractual limitations of various kinds.

A further problem arising from the collective bargaining process is that the inflexibilities of labour agreements may encourage inflexible attitudes and "mind settings" on the part of workers and their leaders, and perhaps even to militant opposition to preserve *status quos* and to obstruct change.

On the whole, unionization and collective bargaining do not appear to coincide easily with dynamic changes in industrial technology. In a world now experiencing an extraordinary acceleration of technological change, this is a reality that labour unions are having considerable difficulty addressing. As a consequence, traditionally strong industrial as well as craft unions appear to be losing power and position. At the same time, companies in new high technology industries remain largely non-unionized.

The heading of this section deliberately refrained from using the word "union". It is not merely labour in the context of union membership and collective bargaining agreements that is relevant to the subject of this discussion. Non-unionized employees are also of vital importance. Often in the struggles of middle management, in the comforts and paternalisms of hierarchies, in the individualistic concerns of the functional professionals and in the cozy and seemingly secure corners in various parts of a business, technological change is a matter to be ignored or abhorred. The capacity of non-dedicated, non-motivated employees to obstruct technological change should never be underestimated.

Morever, such change is often perceived as being in the realms of responsibility of management, the engineers and technicians, and the researchers and planners. Not seen, and frequently without adequate encouragement to be seen, are the long-term self-interest roles that many employees can play themselves (or in small groups) to initiate, facilitate, adjust to, and benefit from technological change.

Nothing in the preceding discussion should be taken to suggest that changes in industrial technology can be easy, smooth or painless. Such changes often do destroy jobs and skills, but simultaneously they create new ones. The full costs of adjustment should not be borne solely by those who are adversely affected. Because business and society as a whole derive benefits from such change, they have responsibilities to ensure that such costs are eased, through adjustment policies and programs. The latter may take many forms. But on the whole these do not appear to be working well in Canada. If one were to choose a single illustration, it perhaps should be that of retraining. Industrial retraining, with some notable exceptions, is not a field in which Canadian business has either strong traditions or good systems. Lack of effort and success tends to be attributed to resistances and fears among employees, or to rigidities in collective agreements. All too few firms have yet realized that a major investment in retraining, largely in their own long-term self-interest, should be a high priority if frustrating barriers to technological change are to be reduced.

Educational Perspectives

The issue of retraining logically leads to larger issues about the role of Canada's educational system in a world of more dynamic and swift technological change.

It has been well documented in the United States that a major deterioration has been taking place — a deterioration that cannot be quickly reversed — in both the quantity and quality of education in those areas that are of the most vital importance to a technologically changing industrial system, particularly the areas of science, mathematics and engineering. Piecemeal evidence suggests that a somewhat similar deterioration appears to have been occurring in Canada.

Technological change is, of course, ultimately the result of the genius of creative minds in applying new and spreading knowledge. Lack of availability of adequate numbers of well-educated and well-trained people in relevant disciplines can thus become the greatest of all possible barriers to technological change.

In this context, three deficiencies in the present educational system would appear to need to be addressed:

— the blurring of focus on technical training among the post-secondary technical training institutions that were largely established in Canada in the 1960s;

— the degree of emphasis on more theoretical and abstract approaches to university education. Growing emphasis on these approaches naturally emerged in the 1960s and 1970s when the university system was exploding, and when large numbers of graduates, especially those receiving post-graduate degrees, were being drawn back into the educational system itself. Now, and for the foreseeable future, the bulk of such graduates must make their careers elsewhere, and therefore require more emphasis, in their education, on applied research and problem solving; and

— the importance of strengthening direct linkage between universities and business and other organizations.

Finally, it is worth recording that the single most important contributing factor to the dramatic emergence of agglomerations of new high tech activities — such as those in California, Massachussetts, North Carolina, Texas and the Ottawa Valley — clearly appears to be proximity to universities or research institutions with outstanding capabilities in fields directly relevant to technological change. This suggests an interesting and controversial question, "If the development of new high technology industry is to be a major Canadian goal, should governments and university administrations be shifting towards a discriminatory allocation of resources to teaching and research in the fields of science, mathematics and engineering?"

Financial Perspectives

It has been long and widely claimed that technological change and new high technology ventures cannot gain adequate access to financing — especially equity and longer-term debt financing, and especially from the traditional and larger financial institutions. Are there barriers here to technological change?

This is a large and complex subject. Major financial institutions have, of course, fiduciary responsibilities — to depositors, pensioners, insurance policy holders, trust funds, etc. — responsibilities governed by law and regulations, as well as by prudence and cold calculations of risk. But over the years, many new types of financial lenders have sprung up to seek opportunities and niches in the financial markets, and to respond to varying needs. Some have been private. Others have been established by governments, both federal and provincial.

In both the government and private sectors, new institutions have focussed particularly on the financial needs of new and small business, often with special attention to high technology initiatives — such as venture capital financing institutions, venture capital activities of large resource-based or other corporations, official development banks and corporations. To these have been added greater leniencies in tax regimes, new instruments (such as Small Business Development Bond), grants of various kinds and low-interest loans. At the same time, private savings and personal financial resources have grown substantially as the nation has generally become more affluent. In this milieu, it is clear that new and small business firms have come to take the leading role over larger and well established firms in the generation of new jobs and new types of activities. Thus, although it is difficult to conclude with categorical firmness that the financing conditions for starting up new high technology enterprises have improved, there is a high probability that this is so.

A more serious question may be posed about the financing problems that may be confronted by a highly successful, exponentially growing firm that has made an extraordinarily successful technological breakthrough, and quickly needs very rapid access to additional financial resources to continue to power its way to a solid, established position. What may be difficult to achieve is necessary financing without the loss of control of the founder(s), since the financing required is frequently equity funds that can be secured only through a merger or through market offerings that disperse ownership.

On the whole, it would appear that even with the accelerated pace, and much more widespread pattern, of technological change, financial barriers to such change have not intensified, and may well have been generally reduced.

Conclusions

We live at a time of immense, complex and accelerating technological change. The overall momentum for such change is not slowing. Indeed, with growing knowledge, generally higher levels of education and greatly increased research, and in the midst of an information revolution of unquantifiable dimensions, a weltering array of technological change is a central fact in the lives of Canadians.

The main focus of the preceding discussion has been on institutional barriers to technological change. The central conclusion is that while there are many barriers, these are not preventing the ongoing tide of change — basically because the human, social and economic imperatives for change are so great.

In fact, a key question confronting Canadians is whether both the overall pace of such change, and more particularly some of the fields and directions of movement, should be more strongly encouraged — in order to achieve, for example, greater national prestige and distinction, and a stronger industrial economy. There are, of course, costs of adjustment to technological change. But there are also costs — perhaps large, longer-term, and often hidden costs — in lagging Canadian technological performance.

It is vital that if faster technological change is to be successfully and appropriately achieved, there should be a parallel encouragement of more positive attitudes to change, especially in the sense of promoting a more diligent search for the kinds of change aimed at maximizing economic and social benefits.

Arthur J. Smith

WHAT ARE THESE NEW TECHNOLOGIES?

Once upon a time
chipping flint was a new technology

In recent years, Canadians have been taking a long, hard look at their traditional resource-based industries, the secondary manufacturing and processing sectors and, with growing interest, the prospects offered by the rapidly expanding science-based industries. It has become increasingly clear that in order to compete and to survive in the post-industrial world, Canadians must not only improve productivity in traditional areas but must carve out for themselves new spheres of excellence in the domain of science and technology.

Despite recent downturns in the world economy, developments in science and technology are moving ahead rapidly. Work is being carried out in diverse fields in many countries and competition among advanced industrial nations is intense. At the same time we are faced with new challenges by a rapidly industrializing third world.

The new age in which we find ourselves is characterized by extensive application of technology to new products and old processes. It offers new opportunities for rapid expansion, enhanced productivity and increases in employment. The industries of this new age are based upon technological innovation applied on a massive scale to information handling, control systems, power generation, entertainment, processing, manufacturing, services and a host of new activities which can scarcely be compared to anything in the whole of human experience.

These activities, these new areas of technological and scientific development, fall into four broad categories: microelectronics, including the major areas of computers and communications; the related area of opto-electronics, including lasers, light-emitting and light-sensitive devices and optical fibres; biotechnology, including genetic engineering, processing, energy and food production; and materials technology which is providing us with everything from new fabrics and adhesives to turbine engines and construction materials.

It is an era in which some Canadian investors are facing bankruptcy, voluntarily closing down enterprises based upon obsolete technologies or are confronted by high quality, low priced goods from newly emerging industrialized countries. For Canadians, two alternatives present themselves, both of which show promise for the future.

We can turn our attention to those areas in which we have traditionally maintained a competitive edge by virtue of possessing scarce natural resources. Here, we can remain competitive in the exploitation and processing of those resources by applying increasingly innovative methods to these traditional activities. At the same time, there are other areas of endeavour, such as communications, transportation, energy and aerospace, where Canadians have achieved mastery in the course of nation building and where we can, with the same determination and instinct for survival we learned from our forefathers, continue to lead the work through continued application of the new technologies.

A Transformative Technology

During the middle years of this century, Canadians became aware that a new age was about to unfold, if not with the suddenness of a thunderclap, certainly with all the drama of a great curtain rising above a vast and colourful stage. The nuclear age dawned; military aviation was perhaps the most visible manifestation of technology, but we were bemused by the post-war explosion of consumer goods, automobiles, new homes and fashions.

Less visible on the world stage, but soon to have even more far-reaching impact, were the invention of the transistor in 1948, the unravelling of the mystery of DNA in 1953 and the development of the laser in 1957.

The pages of mass circulation magazines were often filled with highly imaginative visions of this "future world," which seemed to hold a strong fascination for all. The precise nature of this world of tomorrow was not at all clear to us. Almost without exception, these speculations have proven to be either wildly inaccurate or grossly inadequate. The nature and scope of nearly all the social and technological changes that have swept Canadian society during the past two decades were apparently beyond prediction.

In the past, there have been other technological developments of a profound nature that, over time, changed the ways in which we behaved, saw the world and carried on our daily lives. These we may call "transformative technologies."[1] Their effects are so profound that they bring about significant change in human existence. In the field of transportation, for example, we have seen the development of the railway, the automobile and the airplane, each of which in its way and in its time have annihilated distance and altered our perceptions of the world.

Another distinguishing characteristic of the new technologies is the rate at which change is brought about. In the past, major technologies evolved over the span of one or more generations. The societies which gave birth to them had time to absorb the resulting changes to the way people thought, lived their lives and interpreted events in the light of new knowledge. We have had three generations to internalize the phenomenon of air transportation. The nuclear age, on the other hand, broke upon an unsuspecting world literally overnight, changing forever our notions of warfare, security and international relations.

The commercial availability of integrated circuits in 1961 gave rise by 1971 to the microprocessor. A cascade of products and applications followed, fuelled by exponential growth in computing power and the attendant drop in unit costs. This rate of development can only be described as breathtaking.

These discoveries are recent events. They have taken place over the span of less than a human generation. The challenge with which we are now confronted is perhaps an unexpected one. To what purposes shall we put these new technologies, these new powers with which the human race has been endowed? What does one do with a chip comprising a hundred thousand solid state devices? or a million? or a hundred million?

And what of the eagerly awaited future? the home of the future? the office of the future? the factory of the future? The answer seems to be that the future has arrived. We are living the future now. Its one unassailable feature is change-non-stop, irresistable change.

Microelectronics

We live in an information age. We speak of an information economy and the information society[2]. Handling information has always been a cumbersome task. Anyone who has ever written a concise business letter or personal note knows this. The builders of the pyramids knew this and so did the medieval scribe. We codify our perceptions and our experiences in words, numbers and graphic images. The large scale, high speed storage, manipulation and retrieval of this data has always been a problem. Until today.

Microelectronics, electrical information-handling systems comprising very small components organized on a very large scale, makes it all possible. Digital techniques enable us to reduce language, symbols and pictures to large quantities of very small numbers, mostly ones and zeroes. Computer systems, based on semiconductor technology, store, manipulate and retrieve data in digital form on an enormous scale and at nanosecond speeds (billionths of a second).

Semiconductors conduct electricity (a flow of electrons) in specialized ways. They comprise materials such as silicon, gallium arsenide or germanium, which are grown as crystals with tiny amounts of impurities added to alter their electrical conductivity. Two types, positive and negative, are combined in the transistor. Transistors are used as rectifiers, amplifiers and switching devices, basic components which are combined in large numbers to build electronic devices and systems. The name solid state distinguishes these devices from their vacuum tube predecessors. Solid state devices are smaller, less expensive and more energy efficient than earlier systems. They are constructed in such a way that many individual components can be produced together on a single foundation or substrate. Thus, the "chip" was born.

Much of the manufacture of semiconductors is dependent on thin-film technology. Research in this field is being carried out at the National Research Council's Division of Chemistry.[3] Earlier techniques, some of which are inefficient and wasteful of materials and energy, are being supplanted by new methods such as magnetron sputtering and metalorganic chemical vapour deposition. These techniques enable the creation of films down to 0.0001 millimetre in thickness with a high degree of purity and consistency.

The increasing miniaturization of these systems is leading inexorably toward such fields as modular chemistry,[4] in which an ultraclean substrate is exposed to a chemical bath adding only one sub-unit of a molecule to specific areas of the surface during the course of the reaction. A series of reactions with the same or different reagents builds up molecular "wires" or conductors, insulating regions and switching or memory devices.

Problems to be overcome in these areas include assembly of arrays, organization of components into new kinds of systems and research into the characteristics of electrical devices that are so close to one another that they are no longer discrete entities. One possible outcome of this research is new micro- or nano-fabrication techniques with applications not presently foreseen. Computer- assisted design, increasing degrees of miniaturization, laser, electron beam and photochemical etching and increasingly automated manufacturing processes are giving rise to ever more complex generations of high-density transistor-equivalent devices, including large scale memory storage systems. One such memory system proposed recently relies on the phenomenon of photon echo within a three dimensional unstructured medium which may be crystal, glass or gas. Access would be by intersecting laser beams. Capacity of a system occupying a volume of one cubic foot is estimated at 1,000 trillion bits.[5]

So intense is competition at the international level, that those involved in development and manufacture of integrated circuits (chips) are pooling their resources more and more, particularly in the area of basic research. In the U.S., several chipmakers joined forces in 1982 to set up Semiconductor Research Corp. to organize and sponsor basic research. This year, another non-profit venture, Microelectronics & Computer Technology Corp., was set up to undertake high-risk, systems level research in computers and software.[6] These moves represent a significant reaction to the threat of competition from "Japan Inc."

In Canada, funding comes from a number of federal departments and agencies, though a concerted national strategy for development of any area of high technology has not yet emerged. The province of Ontario has assisted in the funding of two microelectronics development centres which, in addition to research, will provide a manufacturing capability for the custom chip market. Provincial governments, notably British Columbia and Alberta also provide some funding. The federal government has supported the creation of a number of university-based microelectronics centres, to assist industry in applications primarily. The Natural Sciences and Engineering Research Council is setting up a national network of design centres at a number of universities for the development of Very Large Scale Integrated circuits. The centre of Canada's microelectronics industry resides in the Ottawa area. More than 300 companies are engaged in research, development and manufacturing in the areas of computers, communications devices, switching, satellite communications, data transmission and software development, including custom software, computer-aided learning systems, computer assisted design and manufacturing, and commercial development of Telidon, the federally developed protocol for videotex, to provide alpha-numeric and graphic information to homes and businesses via existing systems such as telephone lines and cable television links. Also in the Ottawa area are many companies engaged in laser-optics and biotechnology.

An aspect of computer technology that has received much attention in recent years is artificial intelligence.[7] This has applications in two important areas: robotics and the "fifth generation" computer. Intelligent robotics is expected to have a prominent role in factories of the future, and this will be one of the areas of investigation at the new NRC national research centre for manufacturing and production technology being established in Winnipeg. Development of the intelligent computer has been announced by Japan as an objective for the 1990's.[8] Some North American computer experts are alarmed, some skeptical, while others maintain that if Japanese researchers achieve only half their objectives, they will still have made a significant breakthrough in efforts to dominate the field world-wide.

Canadian accomplishments in the field of telecommunications and, indeed, its importance to Canada is highlighted by the fact that it is now eleven years since the first Canadian geostationary domestic communications satellite was launched into orbit above the equator. It is now ten years since the world's first continent-wide digital data transmission network went into operation, in Canada.

Work in these areas will continue to be of vital importance to Canadians. But it is in the application of new technologies to Canada's traditional resource-based industries that the future lies. The domestic market for new systems, techniques, machinery and equipment, new processes and new products is large and the export potential very great.

Optoelectronics

Information, data, zeroes and ones have to be moved from place to place. If the information is to go a long distance, it will be converted to microwaves and beamed via satellite to the next city or across the ocean. But if it is to move only within the computer or to the next office or across town, it may be converted to light and transmitted via an optical fibre to its destination.

In recent years, new methods of generating, transmitting and detecting light have been developed and harnessed in the interests of science and industry. Visible light inhabits the electromagnetic spectrum from wavelengths of about 700 nanometres (red) to 350 nanometres (violet). Optoelectronic devices operate at wavelengths ranging from about one millimetre (infrared) to 10 nanometres (ultraviolet).

Light-emitting diodes (IEDs) are tiny solid state devices which emit light in various colours and infrared. They consume very little energy, last more than fifty years and can be turned on and off in nanoseconds.

Photocells are solid state devices which convert light to electricity. They are used in communications systems, measurement, calibration, photography and the generation of electricity from the sun.

The laser (light amplification by stimulated emission of radiation) produces light of a single wavelength (colour) and is said to be coherent.[9] Ordinary light comprises a range of wavelengths and is termed incoherent. Coherent light has a number of useful characteristics. Its waves are equally spaced and their frequency is constant. Being of a single frequency, it can be focussed extremely accurately and produce high temperatures. It is not diffused over distance. Lasers may be gas-based or solid, utilizing crystals or semiconductors. They can be electrically or chemically powered and can be pulsed or continuous-wave.

Optical fibres may be glass or plastic. They can be very small, the diameter of a human hair, and bundled in large numbers or used singly. They conduct light in straight lines or around corners, over long distances, with very little light loss.

Integrated optics includes a range of other devices, such as modulators, magnet-optic switches, electro-optic scanners, waveguides, mirrors, lenses, prisms, beam splitters and polarizers.

Some of the leading-edge research, design and application of optical systems have been accomplished in recent years by Bell Canada in cooperation with Northern Telecom Canada and Bell Northern Research.[10] Optical fibre systems have become increasingly important for a number of reasons. Higher bandwidth, compared to traditional copper wire systems, enables the carrying of more information per unit of time, including the simultaneous carrying of data, voice and television image signals. Signals may be carried up to 20 kilometres without regeneration in present systems. This compares to one to two kilometres for copper wire systems. By 1984, improvements will enable this to be extended to 50 kilometres for optical systems. Glass fibres made from silica, the principal component of sand, together with other improvements over conventional data handling networks, may result in materials, installation and operating cost reductions of 30% for inter-office trunk cables.

Biotechnology

An important consideration that arises in any discussion of biotechnology is finding and agreeing upon a suitable definition of the field. In part, this difficulty arises from the fact that some biotechnological activities are an extension of traditional ones such as food processing utilizing fermentation techniques that go back hundreds or thousands of years. The Organization for Economic Cooperation and Development in its report, "Biotechnology: International Trends and Perspectives," published in 1982, after examining a number of recent definitions, settled on the following:

> "the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services."

Biotechnology is dependent upon a multidisciplinary approach to development.[11] Chemical and biological engineering, microbiology, applied genetics, molecular biology, biochemistry, toxicology, biostatistics, forest and foods chemistry, physiology and parasitology are all part of the interdisciplinary science base that has made the recent rapid advances in the field possible. Nevertheless, it is fair to say that much of the interest in the field today is focussed on new applications of recombinant DNA techniques.

Many desirable substances are or can be recovered as byproducts of the metabolism of micro-organisms. Today, it is common practice to alter the genetic material of bacteria, or other organisms, in order to create a particular product. Such products often cannot be obtained in any other way. The way the technique works is this. Plasmids, naturally-occurring ring-shaped structures of DNA, are identified within the cell. Enzymes, known as restriction enzymes, are introduced to cut the plasmids at specific, predetermined points, removing a portion of the genetic material which is discarded. New genetic material is then introduced and, with the aid of other enzymes (ligases) is attached to the original plasmids, closing the ring. The DNA is now said to be "recombined". The bacteria have a new ability to produce the desired substance or product.[12]

The genes thus introduced into the plasmid may have been produced synthetically, built up from protein chains assembled by a computer-controlled "gene machine." Another method of gene synthesis involves identifying a naturally-occurring sequence by spectroscopy and modifying it to resemble, for example, the human gene for the production of growth hormone. In this case, the bacterial product would be synthetic human growth hormone.

Current activities in the field of biotechnology include basic research in genetic engineering, enzymes, fermentation, fused cell techniques, microbial physiology, biochemistry and biomass. Much work remains to be done in systems engineering, both for production of bioagents and industrial applications.

Although Canadian activity in the field has been described as "extremely low," some notable achievements can be cited. The Canada Centre for Mineral and Energy Technology (CANMET) of the Department of Energy, Mines and Resources has developed a technique for the extraction of uranium from iron-containing ores by means of bacterial leaching. Normally, sulphuric acid is used to leach out uranium from ore, but the technique becomes inefficient when soluble ferrous oxide is present. CANMET, however, has identified a strain of bacteria which will convert ferrous oxide to insoluble ferric oxide both quickly and cheaply, enabling the standard leaching process to proceed.[13] Similar techniques are either in use or under development for the recovery of copper, nickel, zinc and other metals.

Researchers at the National Research Council of Canada three years ago succeeded in cloning genetically- altered bacteria capable of producing synthetic human proinsulin, used by the body to produce insulin. Canadian diabetics have hitherto had to rely on animal insulin extracted from 2.5 million pounds of pig, sheep and beef pancreases annually, with attendant side-effects due to chemical differences between animal and human insulin.[14] Recently, workers at NRC's Molecular Genetics Laboratory have succeeded in producing proinsulin using yeast, though commercial production of the hormone by this means has not yet been perfected.[15]

One fruitful area for application of biotechnological methods is Canada's vast pulp and paper industry. Many of the stages in the processing of wood cellulose into paper products are energy intensive, polluting or both. Operations, from the removal of bark from logs to the treatment of waste water, can be improved and made more cost-efficient through the application of biotechnological techniques.[16] In the face of competition from both third world and developed countries, the survival of the Canadian industry may be at stake. Microbial enhanced oil recovery is another area for intensive development.[17]

The federal government has this year announced $65 million for establishment of a major biotechnology centre in Montreal and a plant breeding facility in Saskatoon. Additional funds have been committed for a national biotechnology development program. It is a technology with great relevance to important sectors of the Canadian economy, including agriculture, forestry, fuels, health care, mining, pollution control and the recycling and treatment of waste products. It has the potential to revolutionize certain sectors of our economy. At the same time, its long term prospects are probably beyond our ability to forsee.

Materials Technology

An important area of technological development for many years has been materials, principally metals, plastics and ceramics. Both economic and strategic considerations are spurring the search for new materials and applications. In the United States, work is going forward in finding new alloys to replace strategically important metals. Nickel, aluminum and titanium are being combined in new ways to find replacements for cobalt, tantalum and columbium. Japan, heavily dependent upon imports for many of its requirements, is seeking to substitute ceramics for cobalt, vanadium and chromium,[18] just as it is developing biochemical substitutes for traditionally petroleum-based products.

Resistance to new materials for airframe components from airlines and defense establishments has not deterred engineers in West Germany from long range research in the field. They believe 70% to 80% of secondary components in the next generation of aircraft will be of carbon fibre, including 70% of wing and tail parts, resulting in weight reductions of 20% for wings and 15% to 18% for tail assemblies.[19]

Basic industries are not exempt from the pressures of modernization. In West Germany, the "coal reduction" method of steel production is being introduced. Dispensing with expensive coking plants and blast furnaces, the new methods benefit from lower capital costs and may be carried on in smaller scale plants than previous methods. Cost reductions of $15 to $20 U.S. per ton for pig iron can be enhanced by the recycling or sale of coal gas, a voluminous byproduct.[20]

The glamour material in the eighties is ceramics. Silicon dioxide and nitrogen, the principal constituents of sand and air, when refined and combined with additives and binders, can be injection moulded using techniques borrowed from the plastics industry. Heated, it becomes extremely hard and wear resistant.

Ceramic coatings for high-stress bearings in diesel engines are already in use. Ceramic transducers are employed in sonar for anti-submarine warfare systems. Superalloy turbine blades for marine use currently sell for $250 to $300 a pair. Silicon carbide vanes can reduce those costs to between $5 and $10.[21]

The ultimate objective of much ceramics research and development is automotive engines with major components of ceramics, enabling higher running temperatures, perhaps without cooling systems. High efficiency small turbines for automobiles may become a reality after decades of research. The ability to mould with great accuracy parts previously machined could reduce the need for new robots (and workers) for bending, drilling and welding operations.

In Canada, interest has centered on metallurgy, principally in the service of the hydro-electric, nuclear and aerospace industries. Foreign dominated sectors of the economy have, for the most part, contributed little to materials research. Plastics processing technology in Canada is largely dependent upon resin producers and machinery manufacturers in Europe and the U.S.[22]

Conclusion or Where Do We Go From Here?

As we probe more deeply into the world of the atom, learn to master more of the electromagnetic spectrum and push back the veil of wonder surrounding life itself, it is worthwhile to sit back now and again to ask ourselves, what we are doing? and why? Quite simply, we are learning to understand more of the universe around us and to turn it to our purposes. Human beings are gifted with a boundless curiosity and, on the whole, we tend to make the world a better place in which to live.

Our fascination with the new technologies is the current manifestation of that process and, as Canadians, we naturally have our own perspective on all of this. But in the end it may turn out that the technologies themselves are the greatest resource of all.

Thomas Masters

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TECHNOLOGY, LABOUR MARKETS, AND THE ECONOMY

Canadians, accustomed to more than a century of progress, overwhelmingly expect to be better off tomorrow than today. That progress has been especially vital in the postwar period. Yet now large numbers of unemployed and the prospect that some political or other event could worsen economic conditions have generated widespread fear that a more abundant future is no longer certain and is, perhaps, unattainable. In 1982, in reaction to the perceived reduction in economic prospects in the near term, people cautiously shifted larger portions of their incomes into savings. Meantime, our daily news reports that in the longer term the chip will do all the banking, all the typing and a large share of the editing and legal searches; the chip is also expected to direct machines first to weld and then to assemble all the autos. Often these reports hint that there will be no jobs to go to. No wonder many are expressing their concern about their future and that of their children.

Current events point to a clear need for change in the overall economic outlook for Canadians. We, like most other peoples, demonstrate each day that we are prepared to accept changes that will improve our lot. But massive alterations in our economic relations, such as what we produce and to whom we sell will likely be met with widespread resistance. Nevertheless, Canadians have already begun adjusting to the changing world environment. A dominating characteristic of the second half of this century has been the growing interdependence of the world economy through trade, capital flows, travel, communications, and information transmission. Canadians have been willing participants in this opening of their economy to foreign influences. While only about 20 per cent of the country's output of goods and services were sold to foreigners in the early 1950's, this share has typically been close to 30 per cent in recent years. Similarly, the share of the economy's requirements filled by imports has escalated.

Although our exporters have faced more and more quotas and other quantitative restrictions abroad in recent years, just as Canada has imposed new restrictions, there is little to suggest that economic interdependence will erode; indeed, the opposite is more likely. GATT and trans-national firms, the institutional underpinnings of postwar economic arrangements, will not disappear. More generally, the necessity of maintaining interdependence derives from the almost universally-held conviction that international economic co-operation provides the foundation for improved well-being. For Canada to depart from this reality would cause massive dislocation and is highly unlikely. The problem is that in the current institutional environment the underlying basis for trade will still be least-cost production, so that maintaining competitiveness will be a continuing requirement.

Whether Canada today is generally competitive or not is arguable. The historically strong trade and international payments performance of last year can be explained partly by the sharp drop in Canadian demand, but it also reflects the improved competitive position wrought by depreciation of the Canadian currency against that of its major trading partner over recent years. Regardless of what we think about the current state of affairs, it is clear that competitive circumstances will change. The effects of deregulation on productivity in the United States will not be confined to the transportation industry but are likely to spread into manufacturing and other sectors of that economy. And the emergence of highly productive manufacturers in the Pacific Rim will continue into the foreseeable future.

Failure to keep pace with cost trends among our competitors would have major negative consequences for Canada. We estimate, for example, that each one per cent addition to the annual change in manufacturing unit labour costs beyond those that are consistent with remaining competition would cause an overall employment loss of 100,000 jobs after ten years. Such a rise in unit labour costs also implies annual additions to inflation of almost one per cent, a significantly enlarged current account deficit, and reduced incomes.

Since variations in unit labour costs are the combined effect of changing wage rates and productivity gains, competitiveness can be maintained by slowing wage rate increases or increasing productivity gains. If we accept the view that we are not currently competitive, or that cost conditions among our major trading partners are likely to change quickly over the next several years, then we must accept wage rate reductions, find ways to improve productivity dramatically, or accept the unfavourable consequences outlined above. Improving productivity would appear to be the most palatable choice in the short run. And in the long run, productivity must improve in order to increase real incomes.

Variations in productivity — or output per worker — are derived from growth in aggregate demand, changes in capital per employee, different management practices, improvement in the quality of manpower through education and training, development of scale economies, specialization, and for the economy as a whole, from changes in the industrial mix of output and employment. Thus factors other than technology are part of the explanation of productivity change. But technical innovation does alter the quality of capital and often requires changes in the organization of production. Therefore, productivity changes are an important function of technological change.

All of these factors can cause dislocation, even substantial job losses. The word processors in our offices reduce the number of people needed to produce a given volume of text. No doubt, too, the introduction of robotics into the auto industry will cause significant job losses. But the important point is that these effects should be compared with the threats to jobs posed by failing to adopt more productive processes. We should also consider whether improved productivity creates other jobs.

The Effect on Employment of Technological Change

An ongoing debate centres on the effects of technological change on employment. Here we attempt to evaluate some of the issues and to consider some of the prevailing arguments about what is in store for us.

Most observers of the current Canadian economy argue that future growth of the Canadian economy will require increases of both productivity and employment. Should the economy experience annual growth averaging 3 to 4 per cent in the ten years following 1982, as the consensus argues, we estimate that employment in 1992 will exceed that of 1982 by 2 million jobs and that labour productivity in the later year will be more than 18 per cent higher than in 1982.

Claims that as many as 2 million jobs could be lost in the coming decade from the introduction of new technology are based on the view that the 3 to 4 per cent output growth will be achieved only with gains in productivity; that is, with no increases in employment and a cumultative improvement in productivity of around 40 per cent. But a more reasoned view would recognize that more rapid productivity growth would yield a more competitive and rapidly growing economy that would produce even larger increases in employment than is contemplated by the consensus. Jobs will undoubtedly be lost in the short term from the introduction of technology, but there is virtually unanimous agreement that increases in productivity are positively related in the medium and longer term to increases in the growth of the economy and employment.

There is, of course, disagreement about the precise figures, but Table I provides generally acceptable rules-of-thumb for the relationship between economic growth, productivity, and job gains that should prevail in the 1983-92 period if we have a recovery that is followed by steady growth. During a recovery phase, more than one-half of the economy's growth should come from productivity gains; in the longer term, employment growth will account for the majority of the overall growth. Over the full ten years, we expect that productivity and employment increases will each account for about one-half of the gains in economic growth.

Table I

Output, Productivity, and Employment Scenarios 1983-1992

	Output Growth	Productivity Growth	Employment Growth
	(Average annual percentage change)		
Weak Recovery and Growth	0–3	.25–1.5	.25–1.5
Moderate Recovery and Growth	3–4	1.5–2	1.5–2
Strong Recovery and Growth	4–6	2–3	2–3

The important question is whether the benefits of productivity gains can be distributed to offset direct employment losses. There are several possibilities.

First, if the productivity gain flows from accelerated technological adoption, investment will rise to implement the new technology. The direct effect on jobs will depend upon whether the new technology is produced in Canada or abroad and whether it replaces technology formerly supplied from within the country. On balance we judge that this would create employment, with the amount depending upon the specific technology and the procurement practices of the organization introducing it.

Second, to accelerate technological change, public sector spending on research and development and education is likely to increase. The intention would be to provide a formal background to ease the initial technical adoption of the new technology and the transition of workers from one skill, industry or region to another. The added expenditure would create jobs.

Third, improved productivity necessarily generates more output for the same amount of input than was formerly achieved. The additional benefit may be distributed among several recipients — for example, as higher real wages for those employed, a general reduction in prices, higher profits to the investing firm, and increased government revenues. Added income should induce more consumption by households, investment by businesses, and public expenditures to support the enlarged economy. All of these increased expenditures would generate new jobs.

Fourth, if the productivity gain occurs only in Canada, the costs of production will fall and our trade competitiveness will improve. If the productivity gain occurs worldwide, exports will increase from the larger world economy. Many argue that in either case non-price benefits follow from an ability to trade in higher quality goods than previously exported and in areas not formerly accessible.

Finally, some argue that a strong pro-technology stance provides a "climate" that investors find attractive and that their augmented activity adds to demand and, consequently, growth.

The two key uncertainties that remain about the effects of higher productivity are how the gains are split and whether there are non-price competitive advantages. If new technology were introduced into a highly competitive industry, the advantage of an increase in productivity would accrue mainly to households in the form of higher wages and reduced prices. Their combined effect would yield higher disposable incomes that support increased consumption. In a monopolized industry, the remaining workers would receive some of the gain in higher wages, but a large proportion would be directed to corporate profits, some parts of which might be captured by governments through taxes. Most analysts believe that the overall benefits are smaller when the split favours firms and the government. For our purposes, we assume the split slightly favours the corporations and that the share of corporate profits in national income is raised slightly. Our approach is conservative in that weaker output growth is anticipated than if the additional benefit were directed towards households and in turn, their consumption.

To estimate the long-term magnitude of employment and other global economic effects on the Canadian economy, we have used our national model of the economy to simulate an accelerated technological adoption case. In this exercise we assumed that government spending programs prompt new private investment that accelerates technological adoption beyond what would normally occur. As a result, labour productivity grows an additional 0.75 per cent annually in manufacturing and 0.3 per cent in the financial, communications, and commercial services industries. Overall labour productivity growth rises by 0.25% each year. The effect is tantamount to reducing employment directly in the 1984-2000 period by the amounts indicated in Table II.

Table II

Effect on Employment of ¼ Per Cent Annual Labour Productivity Growth, 1984-2000

	Total	Manufacturing
	(Thousands of person-years)	
1984	4	− 3
1988	− 74	− 48
1993	−208	−132
2000	−399	−239

Because technological adoption does not accelerate simply because people want it to, we assumed that governments provide $1.3 billion of capital assistance to business over the 1984-88 period, precipitating a total increase in business investment of $4 billion in that period to cover the costs of installing the new machinery and processes. These estimates assume that the new capital required amounts to only one-third of that formerly needed to achieve the same output. But as this represents additional capital spending, an estimated 20,000 additional person-years of employment are created over the five years from 1984 until 1988.

When considering the employment effects we also assumed that there are no trade advantages from technological adoption beyond those that follow from price competitiveness. Our calculations may well underestimate the job-creating effects, since others have suggested that non-price advantages would provide one-fourth again as many new jobs as are indicated on the basis of our assumptions. (See J. D. Whitley and R. A. Wilson, "Quantifying the Employment Effects of Micro-Electronics", *Futures*, December 1982, pp. 486-495.)The results of our simulation suggest that the jobs assumed to be lost would be more than recovered by the end of the century, and that most would be recovered before then (Table III).

Table III

Net Employment Effects and Non-Price Trade Effects, 1984-2000

	Excluding non-price trade effects	Including non-price trade effects
	(Thousands of person-years)	
1984	4	6
1988	−35	−25
1993	−62	−26
2000	39	149

Our assumptions are admittedly conservative, and we judge that they tend to bias the results so that our estimates of the job loss offsets are probably on the low side. Others contend that the offsets will be much higher. For example, proponents of increased R&D argue that there are large non-price trade effects, and that they could add considerably to our estimate of the net employment effect (column 2, Table III). Further, some are convinced that, with new technologies, new products and industries are introduced that would otherwise not exist; they believe that a strong emphasis on R &D would improve the investment climate and, therefore, raise overall investment spending to higher levels and expand the overall economy. Neither of these effects is tabulated in our results. But again, as there is some empirical basis to support such propositions, we judge that our estimates are conservative.

Taking all these factors into account, our results show that the economy's output, expenditures, and incomes would be larger from the outset (Table IV). As well, the employed, as a group, would enjoy higher real wages. And, even assuming that government policies affecting the distribution of opportunities and incomes remains fixed, we estimate that the net employment effects are small. Policies can change, however. With a larger economic pie, it seems reasonable to expect that policies could even be twisted towards more employment offsets than are realized in these results and still leave incomes better off.

Another threat to jobs from technological adoption is sometimes perceived. In the capital-savings case, for example, the argument is that the "chip" means that the capital we require for tomorrow's production will itself require fewer materials, energy, and therefore labour than the kind of capital we have needed in the past. For instance, production of a word processor does not require large quantities of steel or machinery. And in many instances the new kind of capital will be able to generate more output per dollar of investment that the capital of the past. These two effects imply that output of producer (capital) goods and services needed to satisfy investment requirements — and Canada's share of foreign investment demand — will be smaller than without the chip, and employment growth in the economy will be reduced.

Table IV

Incremental Impact of High Technology on Selected Indicators 1984-2000

	1984	1988	1993	2000
		(Percent)		
Real GNP	0.2	0.5	1.4	3.4
Consumption	0.1	0.3	0.6	1.6
Nonresidential Investment	1.0	0.8	0.6	0.9
Exports	negl.	0.1	1.1	2.8
Imports	0.4	0.3	−0.8	−2.1
Employment	negl.	−0.3	−0.5	0.3
Wate Rate ($C)	negl.	0.3	−0.4	−2.3
CPI	−0.1	−0.4	−1.4	−3.7
Real Income Per Capita	0.1	0.4	0.7	1.9

The question that then arises is the magnitude of the job loss. Assuming that production in the economy that supplies Canadian and foreign capital requirements is at most one-sixth of total Canadian output and, further, that the associated employment growth is reduced by as much as one-third from past practices, employment requirements would be reduced after ten years by fewer than 100,000 jobs, given that the current recovery is followed by steady growth.

We believe, further, that the estimate of a one-third reduction in employment growth is likely extremely high. Doubtless cases can be cited where output is increased ten or more times with the same real expenditure for new technology, but we believe this is rare. Indeed, the frequently-cited example of the word processor is probably an unfortunate example. In our office, the word processor we require costs $10,000 versus less than $2,000 for an electric typewriter. We do not produce five times more finished text per machine and we presume that, though there may be less steel, the $8,000 difference in cost reflects more materials and human inputs than are found in a typewriter. In this case at least it is likely that the new technology is capital- creating, not capital-saving.

Again the main problem with the capital-savings argument is its failure to recognize the offsetting benefits. Remember that the rest of the world, as well as Canada, will be adopting the new technology and thereby increasing labour and capital productivity. Almost certainly, economic activity worldwide will heighten. In the five-sixths of Canadian production not engaged in the output of capital, exports to the larger world economy and/or sales to Canadians with increased incomes are likely to rise. If this raises output growth by a scant 1/4 per cent annually in the next ten years, more than 200,000 new jobs would be added to offset the 100,000 that might be lost through capital-savings effects.

We conclude from this that there is no significant case to be made for job losses from capital-savings. It is possible, however, that we will face a wave of robotic, telecommunications, point-of-sales, office, and other revolutions that will sweep away large numbers of jobs. Increasing global interdependence of economic activity implies that the pace of change will be at least as quick as it has been in the recent past. Further, given that such a large share of economic activity now involves processing of information, and since some of the major technological changes directly affect that, there is some prospect that changes in organization and the magnitude of the change, more generally, will be as large as those of the industrial revolution and will take as long to absorb.

Our conservative results suggest, however, that the size of the economic pie will be larger and that the recycling of income benefits received by consumers, investors, and governments will in the future generate offsetting job opportunities elsewhere in the economy. Our results, while based on a model of past behaviour, remain valid for the future because, while the alarmist can argue that the pace of technological adoption will be different, he has made no case that consumers, investors, and governments will be more reluctant to spend their income gains than they have been in the past.

This analysis is consistent with the longer record of Canadian experience. Over the last fifty years periods of high employment growth have witnessed high productivity growth, while low productivity growth periods are consistently correlated with large numbers of unemployed. Thus we must begin to think about how we can minimize the problems of adjustment.

Adjustment to Change

The possible magnitude and pace of change mean that one cannot be sanguine about the effects of technology on labour markets, despite their longer term benefits. Major disruptions to employees of particular industries and in selected occupations will occur. For most people, the quickened pace of change implies that they will have to retrain at least once or maybe several times during their working lives.

For the most part, we judge that major technological introductions with potentially the largest effects for current employees will occur in those areas where the technology is or has already been adopted in competing countries. The dislocation of workers could be massive. But we believe the alternatives would lead to even larger disruptions, since jobs would be lost as a result of close-downs or use of protective mechanisms that reduce the real incomes of all households, and thereby the jobs of those who would otherwise have supplied the additional consumer goods and services. Disruptions will, however, occur; and whether payments through unemployment insurance by employers, the remaining employees (now with higher real wages), and from general government revenues to those who have lost their jobs is sufficient compensation is an open social and political question, in which case-specific considerations will always dominate.

Where technological revolutions have already occurred abroad, it is possible to identify areas of vulnerability, though even here the extent of the threat may be dampened because Canadian industry may not face direct competition from foreign suppliers, especially in a highly regulated service industry. To forecast the vulnerability of those who might be affected by technologies that are just being adopted or that lie in the future is, of course, more risky, and generalizations that suggest vulnerability for whole social groups are conjectural at best. Again, case-specific considerations dominate. Not all blue-collar men or all women are vulnerable; rather, men who are employed in the motor vehicle industry and women who are employed as tellers in financial institutions are at risk. And no single social group is exposed to as much risk from technology as farm families were through most of this century.

Our own conjecture is that youth and others who are just seeking to enter the labour force are most vulnerable to the failure of employment growth this decade. For, while many youth are being acquainted with the computer age, the extent of that introduction for most is casual at best. In competing for jobs, their training is unlikely to be sufficient to overcome the informal and formal advantages of tenure held by those who already have jobs or experience. The effect of inadequate experience is exaggerated in times of general demand failure, as is reflected in the current data on unemployment. Barring great good luck, or concerted action by governments worldwide, most forecasters project that subpotential economic performance will continue, and youth will suffer the most from lagging economic growth. If there is any consolation in this for those who fear technological unemployment, it must lie in the certainty that the investment needed to introduce new technology will be risky and therefore weak. Investment will also be weak partly because labour will compete with lower wage rates to minimize the advantages of the new technology. This is hardly a happy trade-off.

More fundamentally, the whole question of technological change points up the need for a restored macroeconomic environment. In a robust recovery, the jobs created would far outnumber any that might be lost to technology. In addition, the improved productivity, resulting from the employment of a large portion of the more than a million unemployed whose productivity is zero, should provide much of the savings needed to create the investment that introduces the new technology.

Compared with the past, we are optimistic enough to believe that the chip and other recent technological changes have played an important part in improving our knowledge of what is happening and of what needs to be done. Partly for this reason, we believe that the difficult-to-achieve but easiest-of-all long-term solution of generating rapid overall economic growth with rapid technological adoption is within reach.

But, in the end, only a vibrant economic environment can create sustained increases in output and jobs and those additions to incomes that can be used to compensate those who suffer dislocation. The choice must be taken to forge ahead and quickly adapt to technological change if we are to meet Canadians' long-term expectation that tomorrow will be better than today.

Finally, the chip and many other modern technologies show promise of providing support to that peculiarly Canadian hope of eliminating regional disparity. For most expect that the new technologies weaken the need for economies of scale and locational concentration as the basis for a competitive edge. Plants, with many small production runs, open the possibility of a more widespread dispersion of the country's production.

M. C. McCracken, C. A. Sonnen
INFORMETRICA

THE IMPACT OF TECHNOLOGICAL CHANGE ON WOMEN

Microchip technology has been hailed by enthusiasts as the key to a "golden era". Canada is already in transition to the post-industrial economy described by futurists as an information society. Indeed, the rapid pace of technological change has prompted a series of studies, reports, task forces and conferences to study the implications of the changes. Some of these have addressed the issue of how the application of new technology will affect women's employment. And all indications are that the initial impact could be severe.

One writer has suggested that "unless appropriate measures are taken" nearly a million women could be out of work by 1990.[1] "Canadian women are on a collision course between their continuing concentration in clerical occupations and industry's apparently diminishing requirements in this line of work," says this author.

But technological change may have much more far-reaching consequences for women than the loss of their traditional sources of employment. The establishment of a post-industrial or information economy offers the potential for women to achieve many of the goals they have sought for a very long time. At the same time, the application of microchip technology, which will usher in that so-called golden era, presents some very real dangers. The danger is that what little progress women have made towards equality in Canadian society will be wiped out in a return to traditional values and old-fashioned ideals.

The direction we take will be determined over the next few years. "Tomorrow is too late," says the Science Council of Canada.[2] We have to plan now for the information society that is already upon us. But unless the particular concerns of women are given specific attention and unless women themselves are involved in the planning process, then the results could well represent a serious setback for Canadian women. Instead of getting a share in the "golden era", they will be left with the dross.

The Adjustment Period

There is no doubt that the next five or ten years will involve some very difficult adjustments. This will be the transition period. Existing jobs may vanish, but new and different occupations may be slow to materialize. And all of it will be complicated by high levels of unemployment lingering on as an after-effect of the worst recession Canada has experienced in more than fifty years.

The application of microchip technology to women's jobs has been well documented.[3] Instant tellers or cash dispensers in the banking industry do away with the need for tellers and clerical workers in financial institutions; computerized terminals at check-out points in grocery and department stores will reduce the number of sales clerks needed; office automation has eliminated much of the paper work previously done by secretaries and typists; computerization of all sorts of other jobs, from telephone operators to mail sorters makes it possible to get through the same volume of work with a much smaller number of employees.

All of these applications have particularly severe consequences for women workers because these are all jobs where women are concentrated. In spite of the fact that women have entered the labour force in ever-increasing numbers over the past few decades, the occupational segregation of women into a limited number of jobs has hardly changed since the beginning of this century. Women have merely exchanged one job ghetto for another. When Canada entered the twentieth century, 61% of all women workers were found in only three occupations: 34% were maids or servants, 14% were dressmakers or seamstresses and 13% were teachers.

Last year, (1982) 62% of all the women in the labour force were found in only three occupational groups: 33% were clerical workers, 19% were in service occupations and 10% were in sales. More than 1.6 million women were clerical workers last year, and these are the jobs that will be most seriously affected by technological change.

The new technology optimists have made the argument that potential job losses as a result of computerization should not really be such a cause for concern. They point out that when computers were first announced into the banking industry, for instance, it became possible to offer all kinds of services that had not been available before. Daily interest accounts, new kinds of loans where interest could be calculated quickly, and different savings options all made their appearance. The increased volume of business that these services generated meant there was no significant loss of jobs because of automation. Besides which, the argument goes, even where it was possible to do the work with fewer employees, no one was fired. The number of employees was reduced through the normal attrition process.

While this may all have been true when microtechnology first began to play a major role in the banking industry, can we use the same arguments in relation to office automation and microchip applications in other work still done mainly by women? There seems no doubt that the process will be infinitely more complex as a result of the recession. While it is possible that the state of the economy over the past two years may slow down the rate of diffusion of new technology, there are other more serious consequences.

More than 11% of Canadians cannot find work. And that doesn't include those who got so discouraged, they stopped looking. As the economy is picking up again and these workers begin their job search once more, they will swell the ranks of the unemployed. This means that unemployment will remain high. The rate may not drop below 10% until almost the end of this decade.

There is another complication. When Canada first went into the recession, in the second half of 1981, many employers dealt with it in the way they often deal with downturns in the business cycle. They implemented hiring freezes, they probably decided not to start any new training programs for the time being, and they may have been reluctant to give big wage increases.

Then when the severity of the recession began to bite, they had to look at other measures. Hiring freezes were not enough, layoffs had to be implemented as well. Employers also began experiencing another phenomenon. Normal attrition rates didn't seem to operate any more. Because the economic situation was so bad and unemployment was so high, turnover rates dropped. Workers who had jobs decided to hang on to them rather than switch to jobs with better prospects or more opportunities.

Employers then began to tighten up and reorganize. Cost-cutting became a matter of life and death. The Conference Board of Canada studied the retrenchment programs instituted by some of the major Canadian employers.[4] They found that for many of those interviewed, there had been a major restructuring of the way in which work was done. That restructuring extended to different industries and, in many ways, to the economy as a whole. It means that many of the jobs lost during the recession will not reappear as economic growth resumes.

Continuing high unemployment will mean stronger competition for those jobs which remain. If women are to be displaced from their traditional job ghettoes by the application of new technology, can they be absorbed elsewhere in the economy? And if so, where?

The "Myth" of Retraining

The likely consequences of the new technology for women's employment have been well documented. Heather Menzies' important book, "Women and the Chip,"[5], written in 1980, presented several case histories. It described specific workplaces where microchip technology had been applied to women's jobs and discussed the impact of change. Around this time, as we might expect at the beginning of a new decade, various task forces and research groups came out with reports about labour markets and unemployment opportunities for the 1980s.[6]

Most of these reports painted a rosy picture. They predicted a decade when major energy projects and economic expansion would create a tremendous demand for labour. Skilled workers would be in such short supply, they said, that there would be serious bottlenecks in manufacturing and construction unless we had a significant increase in immigration of skilled tradespeople. Women, native people and the disabled would play a crucial role. Successful integration of these workers into the full range of needed skills will be essential to prevent massive skill shortages, said the Dodge Task Force. The words have a rather hollow ring in the economic conditions of late 1983. Some economists now believe that skill shortages won't show up again until unemployment has dropped to the seven to eight per cent range, and most projections don't expect that to happen until well into the next decade.

But for those displaced by the new technology, and especially for women, there are two further problems. The first is the difficulty of identifying what skills will be needed. The Dodge Task Force referred to the problem in its report.[7] "...There are great uncertainties about the precise requirements during the decade," said the Task Force, so "the system must be flexible. Changes are required if the system is to meet projected skill requirements and be capable of responding quickly to unforeseen demands."

While it may indeed be true that the information economy will generate all kinds of new jobs — the kind of jobs that don't even exist at the present time — there will obviously be a time lag until those new types of occupation are clearly defined. In the meantime, what kind of retraining should women be getting? At the recent Couchiching Conference, which was devoted to the subject of the human consequences of the new technology,[8] almost all speakers stressed the need for "retraining" for workers whose jobs were being affected by new technology. Yet, when pressed, none of the speakers could identify specific occupations for which trained workers would be needed. On one thing, the experts did agree: in the post-industrial economy, a worker will no longer expect to train for a job and to stay in the same occupation for the rest of her working life. Flexibility and adaptability will now be required of all workers. A worker may undertake training, work at a particular skilled occupation for a while, and then undergo retraining for something else. But until those bright, new jobs of the information age start showing up, it may be difficult to know just what retraining to select.

There seems to be a consensus among the technology "experts" that generalists, who can turn their hand to a variety of jobs, will also be in demand. But all of this seems cold comfort for women who may be losing their jobs right now. The uncertainty is likely to make the transition period that much more difficult.

There is a second problem that women must face when it comes to retraining. It concerns the threat to men's jobs posed by both the recession and the application of new technology. For many years now, women have been counselled to break out of their job ghettoes by training for "non-traditional" occupations. Government programs have offered special incentives for them to do so. And some employers have implemented successful programs to move women into jobs that have usually been considered "men's work." Many of these traditionally male jobs have disappeared, perhaps forever, as a result of the recession. Others are being automated, so that the men who have been doing the jobs up until recently, will also be displaced by the application of new technology.

If women can't train to be tool and die makers because those jobs are now being taken over by robots, will the men who were tool and die makers want to train to be word processing operators? Will high unemployment rates among male workers make it virtually impossible for women to get training and to compete for those few traditionally male jobs?

The Post-Industrial Society — The Dangers

On the face of it, it appears that women may have a particularly difficult time during the period of transition to Canada's post-industrial economy. One writer who has looked at the impact of the new information technologies on women describes the development of women's work as crossing two frontiers. Iris Fitzpatrick Martin, one of the co-authors of "The Conserver Society", and a Research Associate with the GAMMA project, jointly sponsored by the Université de Montréal and McGill University, describes the first frontier when women moved out of the home to take up paid employment.[9] Crossing this frontier was easy, she says, because the kind of employment women took up was mainly an extension of the role they had played in the home. Any loss to husband and children was offset by the financial rewards the woman's work brought. "The essentially domestic nature of these tasks," she says, "does not violate the woman's traditional image; by taking on this kind of work she does not demonstrate any "unfeminine" abilities and does not threaten the power of the men around her."

But when a woman looks for work requiring abilities traditionally viewed as "masculine", Fitzpatrick Martin says, then she is broaching the more forbidding second frontier. "She is threatening to cross the dividing line between the established sex roles, perhaps also to demonstrate that the dividing line has no validity." The obvious question that must be asked in the present context is: will microtechnology and the added effect of the recession push women back behind the first frontier or help them outward beyond the second?

Women have experienced this kind of pressure before, of course. In wartime, for example, women were allowed, and indeed encouraged, to take on traditionally male jobs while men were fighting on the battlefields. Special day care arrangements were made, and government campaigns extolled the virtues of being a working mother, the benefits children would derive from being in day care, and the rewards of doing a "man's job." But once the war was over, women were expected to return to hearth and home, day care arrangements were discontinued, and women were expected to believe there were certain jobs they were not able to do. Some analysts have written about the use of women as a "reserve army of labour."

The same kinds of pressures may surface in the current situation, unless serious attention is given to how they may be avoided. Columnist Jack McArthur, for instance, writing in the *Toronto Star* earlier this year[10], said "we should be asking ourselves whether having an increasing proportion of our population in paid employment really did us much good." "Any family in which both husband and wife works knows that it creates problems," he says, and he asks how much the big rise in multi-job households really added to personal satisfaction. McArthur's analysis, like that of many others, fails to acknowledge the fact that most people don't have any choice in the matter. Both parents have to work for pay because that's the only way the family can survive. And this experience is true, not only of Canada, but of most of the industrialized world.

The implication is that we can deal with our current situation by pushing women back into the home again. And McArthur is not alone. Pollster Allan Gregg stunned an audience of women executives in Toronto back in May with his 1983 survey findings that more than 50% of Canadians think that women should go back to their traditional roles of wife and mother.[11]

Some specific aspects of the post-industrial society may reinforce these notions.

The Electronic Cottage

The kind of changes that are now being implemented as part of Canada's transition to an information economy may exacerbate the situation as far as women are concerned. What Alvin Toffler refers to as "The Electronic Cottage"[12] is already upon us. Many of the jobs now done by women in the work place could just as easily be done by individual women, working at computer terminals in their own homes. Many people have suggested this would be a favourable development.

Interestingly enough, those who regard working at home on their own computer terminal as an ideal situation, are often those who have a good deal of flexibility about when and how they work, and are usually engaged in some kind of creative work. University professors, authors, and journalists, all of whom analyse and write about the technological revolution, are all, perhaps coincidentally, people who can use the technology in a positive way to enhance the quality of their work.

Unfortunately, these kinds of jobs are not the ones that most women do, nor are they the kinds of jobs that employers of large female work forces are now moving into the home.

The negative aspects of the electronic cottage, for many women workers, are likely to come from the expectation that they will be able to process a particular volume of work for their employer, while taking care of home and family responsibilities at the same time. One major Canadian employer, for instance, has said publicly that it has 18,000 clerical jobs, about half of which could be done by women working in their homes. A spokesman for the company said he thought this would be an ideal arrangement because "it would solve the problem of day care."

If this is the kind of approach Canadian employers intend to take, then it will be all too easy to push women back behind that first frontier, forcing them back into the traditional role of looking after the family and doing the housework while engaging in paid labour at the same time.

There are clearly other issues of concern to women that will have to be dealt with as work in the electronic cottage develops. If work is to be done by individual workers in their own homes, they will be increasingly isolated from each other. The attraction of the arrangement from the employer's point of view is obvious. Since the employer no longer has to provide the workplace location, overhead costs will not only be reduced, they will be shifted to the employees instead. Will wages be adjusted to take account of the fact that the employee not only has to do the work, but provide the office or work space as well?

Workers who work in their own homes are less likely to get together to organize unions, or to bargain for better rates of pay or benefits. Some experts have suggested that the very technology that puts work into the home might be used to organize. Individual employees, working on computer terminals in their own homes, may have to be linked with other employees and, it has been suggested, could use their computer connections to communicate with other workers and to organize. While that may be so, it would appear that such a system would not be quite as effective as meeting fellow employees face-to-face at the workplace or at the union meeting.

How would we adapt our labour laws to meet the electronic cottage work environment? Minimum wage laws, labour standards legislation, and so on, where enforcement depends on inspection of the workplace by officials, may have to change if the workplace becomes the private home of the individual employee. Again, the potential exists for regulating even these aspects of working life through the very technology being used by the worker. Word processing operations may be measured by keystrokes, for example, and so standards could be set for maximum output permissable and the minimum pay required.

These issues should be receiving active consideration right now, because work is already moving from office and workplace to home.

There may, of course, turn out to be positive aspects of the electronic cottage. Men's jobs may also move back into the home. Families could work together as a unit in the way that they did before the industrial revolution. Education and learning, generally, may move out of the schools and back into the home. Whether or not such developments would strengthen family units may be debatable. Children may become more involved in working in the family unit and we may have to rethink our attitudes to child labour. With all members of the family spending more time in the home, the demand for housework and the volume of that work will increase rather than diminish.

The point at which almost all workers, men and women, will be working on computers in their own homes, may be some distance in the future. There will always be certain kinds of work that are not easily adaptable to the electronic cottage.

But in moving forward to a post-industrial society, there are real possibilities for the full and equal integration of women into our economic structure. The kind of picture painted by many futurists is one that could hold particular advantages for women.

The Post-Industrial Society — The Opportunities

If the new technology, combined with the after effects of the recession, is going to mean continuing high unemployment, it could also mean that we will have to re-examine our definition of work. Instead of some workers having what we now define as full-time jobs and others having part-time jobs or no jobs at all, all could work shorter hours. We have already had work-sharing arrangements for individual employers where available work is shared between all workers so that no one has to be laid off.

The work environment of the future may mean carrying that concept one step further and sharing the work between all workers. If new technology makes it possible to produce the same amount of goods and services in less time, then improved productivity may make it possible for all workers to enjoy more leisure, without suffering loss of income.

A shorter working week, with more leisure time for all workers, would make it possible for fathers to shoulder their share of family responsibilities in the same way as mothers are already sharing the role of "breadwinner" that we used to assign exclusively to males.

We have set up our workplace to fit the pattern of a male worker who has a wife at home to take care of the house and children. Even though this is no longer the reality for the majority of Canadian families, to "work" or to "have a job" is to work nine to five, to do overtime when requested, to work late or on weekends if you want to get ahead, to be prepared to uproot and move to another part of the country if necessary. Many male workers no longer find those kinds of expectations acceptable, and they are virtually impossible for workers who have the responsibility of children too.

We could use the opportunity presented by technological change to restructure work to recognize the reality of family life in Canada today, where both parents are engaged in paid employment and both could share in home and family responsibilities too.

Along with a redefinition of "work" and a "job" we would, of course, change our perception of "full employment." Perhaps full employment in a post-industrial society is everyone working for 25 hours a week.

Shorter working hours, incidentally, would also make it easier to integrate members of other disadvantaged groups that existing government programs have been designed to help. Disabled people, who are unable to work a full day as we define it now, might be able to work the same hours as everyone else in the new work environment. Native peoples, who want to combine paid employment with traditional pursuits such as hunting and trapping, might find it easier to do this.

The post-industrial society has also been described as one where mass production and large hierarchical organizations are phased out in favour of small production runs and smaller work units. Futurists suggest that work will be carried out by autonomous work teams rather than assembly lines. The information society is collaborative rather than competitive, it has been suggested.

Those concerned with women's employment are only too aware of the problems women face in trying to move up the promotional ladder in Canada's big, corporate hierarchies. If work is to be organized in small, co-operative work teams, then the integration of previously disadvantaged workers could be much easier.

Dealing With the Transition in a Positive Way

It's obvious that the view of the post-industrial society presented by many futurists is one that could offer exciting possibilities for women. The most difficult part will be in the transition period, which seems likely to last for at least the next four or five years. What will we have to do to make sure that the information economy that microtechnology is making possible will not push women back behind that first frontier?

The first step, which should have occurred to policy-makers already, is to make sure that women are involved in the planning process. Self-evident as this may seem, studies are still being done and conferences are still being held to discuss technological changes with only a cursory nod in the direction of women's concerns. Some observers have complained that there seems little point in getting involved in the future when there are so many inequalities to be dealt with in the present. But we ignore the Science Council's warning at our peril. "Tomorrow is too late." If women don't get involved in planning for the post-industrial society now, then it may well be too late for their concerns to be addressed and their needs to be met.

We must make sure that policy development takes those needs into account. At the same time, however, we need to keep in mind the kind of evolutionary change that new technology and the transition to a post-industrial economy could allow. Even people who should know better, like the Labour Canada Task Force on Micro-Electronics and Employment,[13] talk about using technology to help women cope with their "dual responsibilities" of home and employment, instead of asking why they continue to have "dual responsibilities" and whether the technology might not be used to change that.

We should start thinking about what kind of labour standards laws we need to deal with the electronic cottage, for example.

We need a comprehensive family policy to deal with the reality of family life as we are now experiencing it. We have all the elements of it now — family allowances, child tax credits, maternity benefits, deductions for child care expenses, and income tax provisions that deal with families. Many of these provisions were developed in the days when "family" meant father as breadwinner and mother as homemaker and rearer of children. That is no longer the reality of family life in Canada — or in any other major industrialized country for that matter. But we have not yet adapted our policies to meet the new reality.

We could enter into discussions with employers who are now moving work from the workplace into the home to see what kind of safeguards and standards are desirable and would be effective.

We could try to do a better job of identifying what occupations women should be retraining for, and make sure that we are not channelling them into retraining for "non-traditional" occupations that will soon also be phased out as a result of technological change.

Unions are already addressing the concerns of workers who may lose jobs as new technology is adopted. Their discussions could be expanded to look at the implications of a shorter work week and other policies that would help their members adapt to technological change.

Conclusions

Microtechnology does indeed offer the promise of a golden era. The technological revolution could facilitate changes that will benefit not only women, but men and children and entire families too.

For women, it offers the potential of moving out beyond that second frontier and on to the crest of what Alvin Toffler has called the third wave.

The challenge that we face now is that of trying to devise strategies that will get us through the transition pointing in the right direction.

There are no magic solutions. But one thing is sure. We cannot hope to deal with the changes that confront us by turning back the clock. If women are ever going to achieve equality in our society, then the next few years will be crucial.

Monica Townson

Notes

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APPENDIX

The occupational segregation of women

The Labour Force by Industry

Annual averages 1982

(All classes of workers)	'000	%
Agriculture	140	2.9
Other primary industries	34	0.7
Manufacturing	621	12.7
Construction	65	1.3
Transportation, communication and other utilities	213	4.4
Trade	873	17.9
Finance, insurance and real estate	387	7.9
Community, business and personal service	2,190	44.8
Public administration	308	6.3
Unclassified	52	1.1
Total of women in the labour force	4,884	100.0

Source: Statistics Canada, *The Labour Force*, December, 1982.

The Labour Force by Occupation

Annual averages 1982

(All classes of workers)	'000	%
Managerial, administrative	276	5.7
Natural sciences	62	1.3
Social sciences	89	1.8
Religion	4	0.1
Teaching	282	5.8
Medicine, health	416	8.5
Artistic, recreational	69	1.4
Clerical	1,627	33.3
Sales	488	10.0
Service	913	18.7
Agriculture	127	2.6
Processing	91	1.9
Machining	16	0.3
Product fabrication	235	4.8
Construction trades	10	0.2
Transport equipment operation	27	0.6
Materials handling	65	1.3
Other crafts & equipment operating	27	0.6
Unclassified	52	1.1
Total	4,884	100.0

Source: Statistics Canada, *The Labour Force* December, 1982.

THE IMPACT OF INFORMATION TECHNOLOGY ON TRAINING AND EDUCATION

Introduction

Overview

Advances in information technology almost automatically might translate into advances in education and training because the latter surely are informational phenomena. Presumably anything that improves the presentation, flow, organization or use of information is valuable to educators and trainers. Yet the term education incorporates at least two different concepts: the personal experiences of someone coming to understand or appreciate or reflect upon the world; and the organized attempt to produce those experiences. The latter seems closer to information technology.

In preparing this paper I attempted to raise many questions and to suggest some answers. However most complex problems have many solutions, or none, and the suggested answer is not final. Some comments are deliberately provocative and are intended to stimulate critical discussion; others appear so in the absence of elaboration.

I have not paid tribute to the burgeoning collection of machines currently available but instead have concentrated on key issues and a few devices.

At times you may wonder whether this paper is about education or economic development. Because our economic wellbeing depends on an educated/trained workforce and personal income typically is linked to employment, and because public education depends on taxes, and training on revenues, these concepts are intertwined.

The Scope of Education

An educational problem may be far greater than the restricted vision of many observers. Thus an instructional design problem may be considered in isolation but the instructional system itself is embedded in an organization (school, corporation) that has other subsystems with different goals, priorities and resources that interact with it. And this organization, in turn, is embedded with other interacting subsystems in a larger system. In short, the notion of an educational problem or system should be expanded to include more systems and subsystems. And the boundaries between activities that are labelled educational and those that are not, should be pushed back to encompass informal as well as directed learning. Think for a moment about where you learned most of your attitudes, knowledge and skills. Was it exclusively within institutions labelled educational?

A Social Revolution

The world is in a critical phase of its evolution. The opportunity for untold wealth is nigh; so is the possibility of disaster. A Club of Rome report (Friedrichs and Schaff, 1983) suggests that continuous education soon will be a form of universal occupation. Yet most people in the world live in the stick age; they get their energy from burning sticks and their life style centres on hand hoe agriculture. They strive for self-sufficiency constrained by their environment. We, however, are confronted with what some fear could herald a return to that lifestyle (insofar as massive unemployment might reduce our economy to a shambles) and others hope could release mankind from burdensome labour, offering a culturally rich and personally rewarding lifestyle.

At the heart of these assessments is a revolution in information processing spawned by rapid advances in semi-conductor technology which is producing smarter, as well as smaller and cheaper, computers that will go far beyond the data processing systems that were the norm until recently. Robots alone promise to produce half of our manufactured goods, to displace human labour (including cheap labour in developing nations) and to send countless adults back to the education system either for specialized knowledge or skills or for personal education. Who is prepared to cope with this massive shift?

Our leaders in government, industry and education face many complex, inter-locking problems and possibilities. We are immersed in an era of unprecedented changes both in what is possible and in the physical and psychological environment that results from our decisions. Perhaps most significant is the increasing rate of change. We are not yet accustomed to the silicon chip and now must adapt to a protein biochip that promises to increase the density of a chip by 100,000 times. Can we even conceive of the potential impact of such a development on education and training? What we are discussing is a socio-cultural revolution comparable to the introduction of the written word and the invention of printing. How can education and training systems cope? What support is required? Let us begin by considering other developments in information technology.

INFORMATION TECHNOLOGY

What are we to make of the oft-repeated assertion that information processing and communication will be the main occupation of our work force? What are the implications for education and training?

The Promise of Information Technology

In the realm of education and training, information technology holds great promise. By information technology I refer to both the underlying knowledge and the hardware and software tools for storing, retrieving and using numerical, verbal, pictorial and textual information. Usually this involves a microelectronics-based system for information processing and communications, but earlier versions required only texts or simple tools. But information storage and display systems are insufficient. If they were, Edison's prediction (some 70 years ago) that motion pictures would replace the teacher might have been fulfilled.

Significant learning involves something more sophisticated than simple acquisition of information; think of reading, computational skills, ability to draw inferences or compose an essay, or reasoning. As Whitehead put it, "though knowledge is one chief aim of intellectual education, there is another ingredient, vaguer but greater and more dominating in importance. The ancients called it 'wisdom'.... It concerns the handling of knowledge, its selection for the determination of relevant issues, its employment to add value to our immediate experience" (Whitehead, 1929, p. 30).

Technology, including information technology, is feared by some and understood by few. Yet it is essentially a human and humanizing art which is absolutely essential for our survival and wellbeing (cf. Pask and Curran, 1982; Pask, one of the visionary pioneers in this field, shows how computers are changing the way we think about language, knowledge and even consciousness). Technology allows us to do things that we want or need to do. The essence of technology, and therefore educational technology, is knowledge about relationships (e.g. if we perform action X, there is a probability, P, that a given outcome, Y, will occur). Alas in education and training it is seldom clear which action X is most likely to produce the intended result Y, especially without also producing unintended and conflicting outcomes. Operational research is needed to further our understanding.

New products, never before practical, include machines that talk, listen and respond; computers; video recorders and players; and networks that span the world, allowing us to communicate with others.

But older information technology still has an impact. Let me illustrate this point. A three-year old learned what is meant by such terms as fuselage, stabilizer and helium gas, from watching one short television program. A year later he received a plane for a gift and immediately asked why the stabilizer on this plane was at the top of the tail whereas on another it was at the bottom. (Luckily a neighbour could explain the design principles and cost-cutting factors involved; thus a child's knowledge grows.) Yet another three-year old in a nursery school, used a computer-based responsive environment to learn how to read, type and take dictation, achieving a reading level of an eight-year old in 50 or 60 hours of play. What happens when such children enter school? Can their idiosyncratic knowledge be developed? We shall return to this issue later when considering individualized instruction.

Today's systems may include computer-controlled audiovisual devices or even the new laser card—a credit card whose recording stripe can store 2 megabytes, the equivalent of a novel, for retrieval by a cheap attachment to your microcomputer. Moreover it is possible to store not only information but also procedural rules and systems which establish a kind of dialogue with the reader. Whereas books and TV permit voices from the past or afar to influence our knowledge, emotions, values and even actions, they are uni-directional. Even though the author's characters come alive for us, we cannot engage in a discussion with the author. Not so with the computer.

The computer author or programmer may simulate some objects or events, part of his own mind, or the personalities of others. Thus expert systems on a computer allow the mind of an expert to be simulated by the system (Mitchell, 1983). The user engages in a dialogue with the expert (alias the programmer's representation of him or them) about e.g. architecture, office bookkeeping or medical diagnosis. You might even find yourself raising questions, weighing answers and finally agreeing or disagreeing with someone who is now dead! (Shaw and Gaines, 1983).

A situation or process that is too dangerous or costly for students to deal with often may be simulated for pedagogical purposes. Airline pilots who train in a flight simulator sometimes emerge shaking from a simulated near-crash or collision. They learn safely at a fraction of the cost of actually flying. In a training centre electronics students who previously spent 32 hours in class and lab learning certain diagnostic skills now do so in one-half hour with a simulation. (That is an increase in efficiency of 64 times!) With advances in educational technology it now is possible to provide many kinds of learning opportunities that rely on simulating reality in one way or another.

TRAINING

Many jobs require not only initial qualifications but extensive study, some at the expense of the employer, others of the practitioner. The cost of training, unlike education, normally includes the salary of the student while engaged in studies. Therefore many firms have found it profitable to invest considerable sums in an attempt to increase the effectiveness and efficiency of instruction. Any savings in time is a return on the investment. (This is in stark contrast with public education where courses are defined by the calendar and any time saved would be filled by something else.)

It is probably accurate to say that most large companies have extensive training departments though the quality of trainers varies widely. Nonetheless many companies lack any sophistication in this domain. To illustrate, a company engaged in erecting utility poles required its employees to be familiar with safe methods of storing, handling and using dynamite. It asked a summer student to prepare the materials, despite the student's total ignorance of the subject.

Where competent training development groups exist, corporate returns on investment in training often run around 30% to 40%, depending upon subject matter, background of trainers and instructional technologists and media or methods used. I know of one 15 day training course which required 30 person-years to prepare. But the savings in salaried time of new employees over the previous courses justified this expenditure. Of course training is not always the answer to what appears to be a training problem. Holden (1983) presents a 14 step instructional design model for training that includes a chapter dealing with diagnosis and consideration of alternative solutions. Several examples are cited in which training turned out not to be needed.

Media-dependant training tends to be costly to develop. Typically 100 to 500 hours of development are required for Computer Aided Learning. However the Canadian Armed Forces, using the National Research Council's National Authoring Language, NATAL, reportedly operate below this range even with multi-media CAL. With a small number of trainees it is often as difficult to justify CAL in industry as in education. But where numbers warrant it, multi-media CAL may be advantageous. One way to amortize development costs is industry-wide collaboration such as the Kanata High Technology Training Association where common courses are developed for many companies.

Even so, advances in information technology can be expected not only to facilitate training but also to replace it by intelligent systems that reduce the need for training either by automating the process or by serving as a job aid when a particular skill is needed. To illustrate, a portion of a driver training course was found to be 30 times as costly as a mechanical system that achieved the same goal. A humourous illustration is a commercial pilot's lament that the only job requirement now is 60 words per minute typing ability. An example of a smart job aid is an ongoing research project intended to guide electronic trouble-shooting using a multi-media CAL system that one "drives" through a visual map of components and symptoms until the fault is identified and repaired.

KNOWLEDGE AS CAPITAL

The accumulated knowledge of mankind is staggering, whether it be stored in books, minds or computers. As a form of capital, knowledge is needed by individuals, companies and nations to foster their economic aspirations. But it must be used by people or machines, not simply stored. Employees in some industries are constantly studying. Today's youngsters are expected to master in a few decades what required thousands of years to emerge. And new relevant knowledge must be acquired as our society faces rapid changes in work and leisure. What will be the impact of developments in information technology?

A global transformation has begun, one in which human information handling skills are being amplified much as muscle power was in the past. Information technology seems destined to be our main industry. For some this means much study but for others specific knowledge may be less important because current and predicted microprocessor chips make possible remarkable possibilities for storing knowledge in a form conveniently retrievable anywhere by workers. Moreover the use of reprogrammable microprocessor-controlled machines, robots, shifts the burden of knowing from human to computer. This promises to make possible increased production and a sharp decline in the demand for labour. New discoveries, life styles and vocations will require people to adapt and to make the best use of their own resources, not only for productive employment, where possible, but also for peace of mind. The burden of preparing people for this falls on the education system but must be shared by employers and unions.

Increasingly, unemployment due to robots in the factory and expert systems in the office will be a problem. On the one hand these problems will challenge educators and trainers. On the other, maybe some hope is offered to increase the efficiency or effectiveness of instructional systems. Where are we today?

Granted that microprocessors may permit the redesign of our regulatory systems, including education, where do we begin? How do we produce startling improvements?

USING A COMPUTER TO "DRIVE" THROUGH KNOWLEDGE

Let me share a vision with you. Someone decides to learn french using a computer with special tricks. Not only can it present printed or colour graphic information on a colour video display unit but the computer can also present audio information and feedback comments. And it can control slides and TV sequences. Naturally it does so in response to typewritten input from the student (controlled by a program). It also has limited capacity for accepting voice input from the student who speaks into a microphone.

Imagine this student choosing to "travel" to Montreal in this simulator in order to practice her french in a restaurant on rue St. Denis or perhaps to go shopping in the boutiques of old Montreal. The device has the capacity to permit one to walk down a street, choose the direction to turn at an intersection and then be confronted with a slide of whatever lies in that direction. Stopping in front of a shop, one "turns" toward it and "enters"—all simulated by slides or video, accompanied by appropriate sounds. How much more interesting is this than learning exclusively from a book and classroom? Note that this system could be used at work or home and would be useful for most subjects. Is this a dream?

Just such a computer aided learning system exists and audio-visual materials for the french lessons are being recorded in Montreal by an American company even as this paper is written. The dream was that a Canadian firm would be doing it, creating opportunities for an indigenous knowledge industry.

From Blacksmith to Wordsmith

Let us extend this vision. If our workforce is increasingly less likely to work in manufacturing industry we must exploit opportunities for new industries based on information technology. Production of CAL software for such a learning system could utilize a variety of talents, including those in training centres and universities.

Suppose a Canadian company were to produce CAL lessons and courses for a wide range of academic and vocational subjects, selling them in the world market. Not only would it enhance education and training but it would provide jobs for Canadians and it would contribute positively to our international balance of payments. What more could we ask?

Cultural Implications of the Knowledge Industry

What are the long-term implications for our culture if we import rather than produce such learning materials (with appropriate consideration given to Canadian issues, values and goals)? Problems with foreign-authored texts can be complemented by our teachers but an adaptive self-instructional system may be used at home, workplace or even school without human intervention. It is imperative that educators and other decision makers be aware of the long-term possibility of cultural diminishment with sophisticated CAL.

Should Canada develop an instructional software industry as a national priority as we have with broadcasting, film production and the Canadian publishing industry? If information technology is expected to lead in economic growth, how best to create these jobs and prepare people to fill them? Colleges and universities can provide the necessary preparation (and do so now on a limited scale) but might also engage in the necessary research and even in lesson production.

Let us pursue this path further. The inter-relatedness of information technology and education is apparent already. But what about their links to societal development and change? Let us return to the American company that is developing the language series. For a key question concerns the effectiveness of such instruction. How useful is this kind of CAL and how much time does it take compared with conventional teaching?

WILL EFFICIENT TEACHING PRODUCE BRIGHT STUDENTS, SOCIAL PROBLEMS, OR ...?

Consider the implications of work currently in progress. This company is busy packaging teaching materials which combine CAL, computer-controlled slides and TV (video disk) and audio—as well as specially designed printed material. All this is intended to implement the curriculum stipulated by the state department of education. (We hold in abeyance any consideration about whether children should be taught this way because such normative issues are likely to be swept under the table by decision makers; a combination of the profit motive and budget restrictions will demand it).

Suppose they are successful and more-or-less fully automate the teaching of grades 5 to 12 as intended. Suppose further that the materials are modified to suit virtually any state or provincial curriculum. By allowing amortization of development costs over many schools it is likely that such a system could be very much cheaper than the traditional, union-bound school system. As such this kind of commercial system conceivably could replace our schools. It might even be sold directly to parents. How effective is this system?

I have been told that the content of grades 5, 6 and 7, as well as part of grade 8, was available last year. A demonstration project was undertaken in a pilot school. Reportedly, grade 5 children progressed through to grade 8 in about five months! Think about this for a moment.

At that rate, the grade 5 students might complete high school in about a year. Would they enter college or the job market at age 12? Would they be better students than those from a traditional system? If they enter college/university, what happens to their social life? If not, will they be jobless and a social problem? Will the schools use this system and then cram more into the curriculum to keep folks there until age 16 or 18? If so, what are the implications of one group's having a relatively much higher level of formal education than heretofore or than other groups? On the other hand, suppose the USA and other nations buy this sort of school system and Canada does not? Our graduates, indeed our economy would be at a disadvantage. What if private schools adopt it and the provincial system does not? Presumably many parents would send their offspring to the private school. Or perhaps it would produce great pressure for public implementation. But if so, will this be seen as a way of cutting government expenditures? If your school board or province does not use this system and another does, your children may suffer, forcing you to act.

The cultural overtones implicit in having a foreign dominated CAL-based educational system, coupled with the need to promote employment of our graduates, leads to a simple conclusion that underscores an earlier point: We cannot afford not to develop our own version of this multimedia CAL system (assuming extensive evaluation confirms early reports).

THE UNIVERSITY OF TOMORROW?

The Americanization of Canadian Universities

The emergence of interactive multi-media computer systems with video-disk colour TV that can store some 50,000 pictures or 4,000 books on a disk costing a few dollars, cheap computers programmed for a specific instructional procedure (e.g. a talking book), and increasing interest in tele-education schemes, all presage a radical shift to home and job-based education. Moreover American private enterprise stands a very good chance of controlling this aspect of information technology just as much of the Canadian publishing industry is a branch plant operation. To illustrate, Texas Instruments already makes hand-held talking computers for learning in elementary grades but in principle could shift levels. And there are other models.

We are all aware of the existence of highly qualified scientists, engineers and others in big corporations. Many engage in research at the frontiers of knowledge. What would happen if one of them decided to develop and open a CAL system at the university level? Not possible, you say, because universities are established by government charter? Consider this: in the USA several such companies have degree-granting powers and actually offer bachelor's level education and some even offer master's and Ph.D. degrees. The fact that these programmes are intended for their own employees does not preclude their opening to include anyone.

Rumours exist of a multi-million dollar federally funded project (in collaboration with a western province) to establish in all post-secondary institutions, facilities for CAL controlled by a private corporation's computer in the USA. If so, would this export jobs as well as money? Surely Canadian facilities could be found.

Tele-Education

By tele-education we mean a system of education or training in which the learner is usually separated in space or time from the subject matter expert for most of his instruction. Thus tele-education might occur over an extended geographical area through direct or interactive systems (e.g. Telidon, cable-TV, satellite communications or computer). Or it may use other self-instructional schemes. Note that learning at great distance is not necessary and differs little from learning on campus or in a corporate training centre using the same instructional resources. The main ingredient is the knowledge engineering process that produces high quality self-instructional materials.

There have been several notable, and mostly large, experiments which demonstrated the efficacy of distant study schemes. Britains's Open University is perhaps the best known; OU students spend about two-thirds of their time with printed course materials, the rest is distributed across radio, TV, computer-scored assignments and personal discussions with one of the 5,000 tutors scattered around the UK. The OU may allocate five person-years to develop a course (which is perhaps 20 times the time available in a typical university). But with 5,000 or more students in a course, the payoff to develop instructional materials is great.

Canada has several tele-education schemes. The largest is probably Tele-Université (a component of l'Université du Québec). But it should be possible for several universities to co-operate, perhaps with a national agency, to develop high quality instructional materials and systems that could be used at other institutions. This would reduce some costs and free faculty members to spend more time with students and in research. We could even establish a trans-Canada distribution system similar to British Columbia's Knowledge Network of the West. This could act as a catalyst and public utility for dissemination of media programs to anyone who chooses to watch as well as to registered students.

The Information Marketplace: Multi-National Growth Industry?

Already available is an increasing flow of CAL software for home computers, mainly at the elementary school level. Will we someday be treated to a learning menu distributed to our home computer by an American university (this exists today) or company or perhaps available from our telephone or cable TV company? What would happen to Canadian institutions then? Will some Canadian universities become essentially research centres and schools of graduate study? Will others emphasize software production? Perhaps students actually should have more rather than less contact with faculty members as many have asserted. We must conclude that tele-education may be a last resort for some while yet preferred by others. Let us strive to keep our universities viable.

The impetus and means for educational change is shifting from ministries of education and teachers to a commercial marketplace dominated by corporations not known for their sense of ethical, social and cultural responsibility for the organization of personal and cultural development. We must establish a dialogue with others to determine the kind of future we want.

Provision of opportunities for quality education is not simply an "educational" problem, it is a political, economic, social and global industrial problem. As a socio-cultural regulator we must consider education not only at the provincial level but also at the national and at the local level. But the details will require research as well as discussion and compromise before an ideal solution is found.

The Computer Goes to School

The spurious saliency of micro-computers and promotion of computer literacy obscures the fact that our homes are full of telephones, motors, etc. about which we usually know nothing. Granted that computers are important, it is not clear whether we need to know much about them. Tom Rich (1983) provides an excellent overview of the impact of computers on Canadian schools. His conclusion is sound, we still do not know what will happen if extensive use is made of these machines. Yet most provinces have or will install computers in all schools. Both Ontario and Quebec even plan to establish computer factories for the education market. And most provinces have policies and school-centred user groups for mutual support.

In principle there are several possible uses of a computer in school: as a calculator; as a word processor; as a problem solving tool (e.g. simulator); as a teaching/ learning aid; as a controller of processes (e.g. robotics); as subject matter; as a means to learn programming. In practice, apparently most schools stick to programming and studying what is a computer. Programming may prove more useful as an introduction to disciplined, rigorous thinking than as a usable skill.

Perhaps software costs prohibit widespread introduction of CAL. Undoubtedly, more and more computers will find their way into schools and the sophistication of students who use them is likely to be impressive. But a massive effort is needed to prepare teachers for this invasion. This calls for courses, self-instructional materials and perhaps CAL. We could use a national consortium to share materials.

FROM POCKET CALCULATOR TO POCKET PROFESSOR

Pocket-size flat screen video display units now exist and the Science Council of Canada (1982) predicts a pocket computer more powerful than any of today's multi-million dollar machines. What problems and opportunities can we foresee? What research should be initiated?

It seems certain that hand-held CAL will become available, bringing to the student the best teaching and learning strategies (and knowledge) of some of our greatest teachers. The ubiquitous pocket calculator may be replaced by a pocket prof designed to guide the student through a specific subject matter. Needless to say, this will call for curriculum changes. But it also demands much research if we are to implement this notion.

Artificial Intelligence and Expert Systems

One area for research concerns the development of expert systems and artificial intelligence (A.I.). Where are the funds? Both SSHRC and NSERC should establish strategic grant programs to support such work and in information technology generally. Should the Government of Canada treat CAL as a national priority and perhaps establish R and D centres within the National Research Council's CAL group, in the Department of Communications or at key regional centres? Or can we afford only one such centre with a budget to attract world class researchers in cognitive science, philosophy, educational technology, computer science, cybernetics, etc? We need not be so restrictive. Canada now has talented researchers who rely mainly on foreign sources of funds; how long can we keep them without massive support?

Modelling Knowledge, Learners and Conceptual Style

Any CAL system based on A.I. must incorporate a model or representation of the tasks or subject matter to be learned. Equally it needs a representation of the student's knowledge and of his capability for carrying out required operations. And it needs a representation of alternative teaching/learning activities that might be matched to the student's needs. Finally it needs a learning model which monitors student-tutor conversation and computes the probabilities of the student's interests, preferences, needs, etc., in order to make inferences and provide the best possible information and manner of presentation. By way of illustration, one USA-funded Canadian research group (at Concordia University's Centre for System Research and Knowledge Engineering/Centre de recherche systemique et d'epistemologie appliquee) is examining several inter-related questions that need to be answered first: How to analyze and represent the organizing principle binding related concepts, procedures, relations, etc. together? How to identify and match conceptual styles? How to develop a curriculum for individualized learning? And how can these tasks be carried out by a computer? From work such as this may come the knowledge needed to individualize instruction through CAL; until then, most programs are likely to be simple drill-and-practice or teach-and-test units. Valuable though these be, it is not equivalent to having a dialogue with an expert.

Such research and development, aimed at implementing an effective form of individualized tutoring could prove useful not only at home or school but in the workspace as well. Even employees and managers could converse with this system about information pertinent to decision making. But where is the money to come from to support graduate students and research associates? One thing is clear, money must be found now to train Canadian researchers in all aspects of educational and information technology. Tomorrow is too late.

THE IDEA OF INDIVIDUALIZED INSTRUCTION

As today's students experience—outside the classroom—an information cafeteria containing multichannel TV, books, computer games, chip-based instruction, and discussions, their knowledge becomes increasingly complex and unique. Unlike mass instruction, or self-pacing through common CAL or other software, individualized instruction implies adaptation to individual differences in conceptual style, preferences, attitudes, background and intention. Here we confront the most vexing aspect of educational technology.

The Teacher Must Have a Model of the Learner

To ignore the characteristics of the learning system when we design an instructional system is to guarantee a mismatch much of the time. Research shows that synchronization of only two teaching/learning styles produces as much as a tenfold increase in learning rate for matched over mismatched styles. How can educational technologists talk of individualizing learning when such basic individual differences are ignored? Typically only one instructional activity or sequence, or at most a limited form of parallel versions, is developed. Adaptive systems are expensive but can be constructed even at this early stage of research on A.I.-based CAL. But this appears to be too costly for isolated workers to manage. Perhaps a national CAL publishing house or clearinghouse and marketing agency is needed.

Equally important, instructional technologists ignore most of the research on learning that shows the futility of attempting to invent instructional methods and materials that routinely produce intended—but narrow—instructional outcomes in students. One result is to dehumanize the student by treating him as an object rather than an active, self-determining person with idiosyncratic tastes and capability. Another is to encourage a superficial learning strategy rather than a deep, holistic approach to understanding the subject matter.

Conceptual Style

Gibbs (1981) reports a study at Harvard in which students were asked to read an introductory text for 20 minutes. They were given a multiple-choice test; all did very or exceptionally well. They were then asked to summarize the chapter in a sentence or two. You might imagine that most could do this; only one percent could do so. The remaining 99% apparently did not attempt to find out what they were reading. Such obedient purposelessness probably is not unique to Harvard students. It gives rise to a simple question: What was their understanding of 'learning'?

Students can be characterized as having an active or passive attitude to learning. The latter sees learning as something that happens to you whereas the active student sees learning as something you do, including searching for understanding and not merely skimming the surface to remember enough to pass a test. To this must be linked Capra's (1982) view that our education system is a product of the mechanistic paradigm that has dominated scholarship for several centuries and which is analytic rather than holistic. As a result, there often is a great concern with efficient transfer of information rather than with a development of thinking individuals. Ideally, individualized instruction systems should promote the active approach.

Of course there are other alternatives. One would be to help students to learn how to learn. Perhaps students can be helped to acquire an active, holistic approach to their learning so that they can understand and not merely recall what they have studied. They might also learn to concentrate, to read flexibly and quickly to solve problems easily, to take notes that reflect patterns, etc. Or they may learn to communicate and discuss critical issues.

Another model that comes to mind is the University of King's College in Halifax whose Foundation Programme provides a stimulating mixture of large classes, group discussions, tutorials, and informal discussion combined with an incredible array of reading materials from ancient to modern times and spanning art, science, religion, philosophy, etc. Doubtless CAL would help, but in a very important sense, King's students have an individualized education system already.

EDUCATION AND EMPLOYMENT

Changing employment patterns underscore the importance of exploiting new possibilities of employment and socially worthwhile activities.

Information technology with all its ramifications for research and development, communications, robotics, education, cybernetics and better organizations, provides many opportunities for creating employment. Equally—if we fail to act as a nation with a sense of urgency—it provides opportunities for other countries to create employment and to sell their goods and services to us. The shift in balance of payments, from producer/exporter to importer of hardware and software could represent a difference of $10 billion to $20 billion per annum.

Because technology is inextricably intertwined with education, it follows that more money must be directed to higher education as well as to research and development if we wish to prepare people for new roles.

How will people acquire the requisite skills to function in the information technology age? We can expect to see increased emphasis not only on schooling, university studies and job training but also on retraining to help those displaced by machines. For many, retraining may be difficult, for others, impossible; we need to find new methods that make learning easier, more enjoyable and, if possible, cheaper than the approach followed for the past century or so. Moreover we need to help people adapt not so much to change as to the increasing rate of change: change in knowledge, technology, machines, methods, jobs, lifestyles, society. How can educational technology help each person to maximize his learning potential despite wide variations in individual capability and changing needs? One way is through recognition that education is a cradle to grave activity.

Lifelong Learning

We may think of education as being focussed on the optimal organization of personal and cultural development. This implies continuity from its genesis at a parent's knee to death. Education is not confined to schooling. Recall that until recently conversation was the mark of an educated person. Today knowledge and education are crucial national and personal resources. The educated person engages in a lifelong process which contributes to both personal and national development. Thus education, work and leisure intertwine. Often only a paycheque distinguishes between learners.

Meanwhile the world's so-called education system grinds on, consuming ever-increasing amounts of money. While rich countries provide tax-supported schooling for 10 to 20 years, half the world's children cannot attend school. Enormous problems must be solved if mankind as a whole is to share in the potential for human comfort, achievement, and wellbeing now restricted to a tiny minority. What if Canada were to develop a new approach to education and training, one that could be exported to developing nations and involving Canadians as resource persons and consultants? Developing nations might leap into the 21st century with our aid.

But first we must consider our options.

WHAT IS NEEDED?

National Survival

Education and training in Canada is a multi-billion dollar enterprise and even a one percent increase in effectiveness would be important to that half of the population directly involved. However the real concern of government is not the need for training and retraining. Rather it surely is national survival in the face of intense competition. In this respect, the multi-billion dollar software market on the horizon suggests that federal and provincial governments foster the development of Canadian expertise in information technology in general and educational technology in particular.

We may well have an opportunity window of only two or three years; during this period we could see a Canadian software industry grow rapidly, otherwise we may experience a brain drain as well as an exodus of money. Shall we see a national priority animated by a sense of urgency and a vision of what kind of future we want? Should there be a national college or university, perhaps operating as a Tele-Education system yet integrated with existing universities? The Canadian Association of University Teachers and the Association of Universities and Colleges of Canada might be encouraged to work on this before a multi-national company does it.

Government Training

Government can do much to help simply by taking existing government and defense training needs and orchestrating them to support the emergence of an indigenous Canadian educational/information technology industry. By so doing, our future could be far better than if we export money, jobs and even responsibility for much of our cultural development. Funding of Canadian research centres and individual scholars is needed.

Should Canada be more active? Other governments have been the dominant force in high-technology activity. Japan's massive fifth generation computer project is parallelled by a software development centre. The USA, France, the U.K. and other countries are actively pursuing this area. Of significance is that a tiny country, Singapore, has decided to develop a software industry. The curriculum in existing institutions is being modified to include computers and an Institute of Systems Technology set up to offer training courses. Similarly an Institute for Systems Studies is planned. Various incentives, some very enticing, were identified to support the software industry. Singapore realized the difficulty of competing with industrial giants in hardware manufacturing and marketing. The global market for CAL and other software is just beginning.

A National CAL Software Repository and Marketing Programme

A valuable addition for education and training would be a standard course storage protocol, a national

CAL software storage and management system and a marketing programme. All of this could be built around NATAL, one of the few languages that is relatively machine-independent. NATAL can operate a variety of terminals, including Telidon.

Just as publishing as we know it would not exist without the many government programmes to support Canadian publishers and authors, so too might Canadian computer software publishing be very limited without similar programmes. Another model is the National Film Board which has produced and distributed many excellent films; a similar agency might undertake to develop computer aided learning and other software. In the U.K. the B.B.C. offers a computer literacy course which includes not only books, radio and TV programmes but also a cheap computer; and the B.B.C. broadcasts computer programs which users record on a cassette recorder. Such a model could be imitated to distribute free software here. Another approach to distribution may be to establish a Canadian CAL software development fund. Similarly a central clearinghouse and marketing agency might aid thousands of cottage industry software creators.

Training Development

Some countries levy a training tax on corporations that is either given to the company for training or to a consortium for industry-wide training materials. Such a tax incentive could do much to improve training materials and perhaps to develop a CAL software industry.

A National Centre for CAL Research

A Canadian centre or network for CAL could do much to coordinate activity here. (We interpret the term CAL in its widest sense as being concerned with the design, programming and use of systems for creating, processing, storing, retrieving or communicating information. It is thus concerned with knowledge engineering, expert systems and perhaps even robotics as well as learning.) This centre should be a central organization for promoting the development and application of CAL and other aspects of educational technology in Canada. It could: be a focal point for collecting and disseminating information, advise government and corporate decision makers, initiate research and development programmes, and engage in other socially worthwhile activities.

Although the proposed centre should be financed by the federal government and, ideally, have a direct link to the Cabinet, several options exist for implementation of this recommendation, e.g. a new agency, a new department in an existing government department, a hybrid consisting of parts of two or more departments, a new institute established e.g. at a university. Such an institute might be set up across the country in various places. Perhaps a model to consider is the CAL group in the National Research Council.

Another key question is whether, and how, money can be allocated to support relevant research and development. Some sort of granting agency is required to support all sorts of things: research and development groups and centres; software publishing; scholarships for students and returning students, aid for education of foreign students, etc...

A Model of Canada

Finally, the proposed centre might be established as part of a national Institute for Cybernetics devoted to developing a model of the economy as a viable system (Beer, 1979). When dealing with systems as complex as human systems we must recognize and cope with the fact that everything interacts with everything else, thus invalidating the traditional analysis and reduction of problems into isolated subproblems. We also must recognize the the observing and the observed system interact; there can be no objective observer. We also need to appreciate that the use of exclusively quantitative data is unsatisfactory. Finally, we must recognize the ethical and aesthetic variables which must be integrated into analysis, planning and decision making. This undoubtedly calls for a trans-disciplinary activity.

There ought to be a cybernetic model of the nation available to the Cabinets of the national and provincial governments. The complexity of inter-related systems with many feedback loops demands that our governments have the best tools available to govern. Our very future depends on the leadership to establish them. Such a viable system model, incorporating education, information technology, etc., as components, would be of inestimable value in establishing government policy.

Conclusion

We have considered a richer and more dynamic model of education (with its subset, training) than is usually discussed. I have tried to show that education is a critically important factor at the individual or national level. Moreover education, work and leisure are intertwined and continue throughout life.

In this world of nearly unlimited computing power and instantaneous worldwide communication, the central question posed by information technology is political. What kind of society do we Canadians wish to create for ourselves and future generations? Second to this is the means to use.

Will we harness the computer and use it for everyone's benefit or will it simply be a tool for one group to exploit another? Will Canada develop a national policy on CAL software production and other aspects of educational/ information technology? All we need now is someone to build a viable system model that provides a vehicle to steer our education and training sector through a rapidly changing economy and builds on the expertise of everyone. It can be done; all we need is courage, initiative and commitment—and awareness of the potentially disastrous effects of indecision.

P. David Mitchell

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Science Council of Canada (1982), *Planning Now for an Information Society, Tomorrow is too Late*. Ottawa.

Shaw, M. and B. Gaines (1983), *Computer Systems in the Knowledge Environment: A New Medium*, in G.E. Lasker (ed.) *The Relation Between World Problems and Systems Learning*. San Francisco: Intersystems.

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SELECTED BIBLIOGRAPHY

THEME I — TECHNOLOGY IN CANADA'S FUTURE

Ian Barron and Ray Curnow, *The Future with Microelectronics: Forecasting the Effects of Information* Technology, Frances Printer, London, 1979

One of the best of several books discussing in fairly general terms microelectronics and its applications. The book draws heavily on British experience and provides perhaps the most widely quoted analysis of the longer term impact on employment of the new technologies.

Michael L. Dertouzos and J. Moses (eds.), *The Computer Age: A Twenty-Year View*, MIT Press, Cambridge, Mass., 1979

This set of original essays done for the American Bicentennial draws on M.I.T. and other experts to examine the full range of computer developments, applications and implications currently and within a twenty year time horizon. The book is especially interesting in that it provides leading experts the opportunity to informally speculate about future developments in areas where they will be among those creating those developments (Nicholas Negroponte computer graphics; Terry Winograd; artificial intelligence; Seymour Papert, computer aided learning, etc.)

Direction des Études Industrielles, Ministère de l'industrie du Commerce et du Tourisme (Que), *L'Industrie et l'Électronique au Québec: Analyse et Perspectives*, Québec, 1981

This is a sector study of the electronics industry examining the current state of the industry in Quebec within the Canadian context; its organization and structure; its factors of production; and its markets. The study concludes by examining those elements required for developing and extending the current levels of activity.

D. Godfrey, J. Madden, D.F. Packhill, A. Ouimet, *Gutenberg II*, Press Porcepré, Victoria, 1980

D. Godfrey, E. Chang (eds.), *The Telidon Book*, Press Porcepré, Victoria, 1981

In *Gutenberg II*, several of those active in the development of Telidon, the Canadian videotex technology, describe the system and with others review their vision for its development. The image is of a mass medium for interactive computer communications finally bringing to fruition the continuing Canadian vision of the "wired city" and the "wired country". The Telidon Book carries the vision into the market place and there is a strong emphasis on the practicality of implementing and marketing Telidon domestically and internationally and on the technical details of videotex systems.

Pamela McCorduck, *Machines Who Think*, W.H. Fruman and Co., San Francisco, 1979

Written by a non-professional for non-professionals this book provides a history of artificial intelligence as a discipline and as a technology. In its course it also gives a useful introduction to the techniques of AI, the sub-disciplines of AI, such as expert systems, natural language interfaces and robotics and presents some of the outstanding ethical, philosophical and technical problems.

Ministry of Industry and Tourism (Ont.), *Background Papers for the Government Microelectronics Task Force*, Toronto, 1981

The Government of Ontario developed a series of background studies for its Task Force on Microelectronics. These papers reviewed international and Canadian developments in such areas as the electronics industry, software and the rate of diffusion of microelectronics based innovations and looked to situate Ontario within this context. In addition, the various electronics based markets were analysed for current and potential Ontario opportunities.

Le Monde, *L'Informatique Aujourd'hui*, Paris, 1982

This is a collection of the articles published in *Le Monde*, one of the world's finest newspapers, on the subject of informatics (information technology). The topics covered include the technologies, policies, applications and impacts as well as a very useful glossary and bibliography of French language documents. As an account of the intelligent observer experiencing and responding day

by day to the events precipitated by the microchip this collection is extremely useful even if disjointed.

Nature, Special Issue on *Biotechnology*, January 10, 1980

Written for the layman interested in science, especially the natural sciences, this issue provides a good introduction internationally to the opportunities, issues and concerns surrounding biotechnology. The position taken is that there are significant industrial opportunities to be exploited but there are risks both to science and to society in their exploitation. There is a useful description of areas of possible development and the historical background to the current burst of interest.

J.-M. Salvador, *La Bureautique au Québec*, Ministère des Communications, Québec, 1983

This brief document is one of a series of studies prepared as background to a major Quebec conference on communications held in October, 1983. The study reviews the current status of Quebec's participation in the production of goods and services in the area of bureautique/office automation.

Scientific American, Special Issue on the *Mechanization of Work*, September 1982

This issue brings together analyses of the mechanization/ automation of several different types of work: agriculture, mining, design and manufacturing, commerce and office work along with several more general pieces. While no specific technology is significant, the combination of several technological developments is having transformative effects in most of the areas analysed.

Science Council of Canada, *Biotechnology in Canada: Promises and Concerns*, Ottawa, 1980

This document provides the results of a workshop during which the range of issues presented by biotechnology industrial developments were discussed. Industrial opportunities were identified as were the limitations on Canada's capability in responding to those opportunities. Certain of the medical, ethical and legal problems presented by biotechnological research were also noted.

The Special Committee on Alternative Energy and Oil Substitution, *Energy Alternatives*, Supply and Services Canada, Ottawa, 1981

This study by a Special Committee of Parliament examines the current "energy system" in Canada and analyses the possible role of a variety of alternatives to this including the use of alternative energy sources and alternative energy technologies. The report provides a very useful compendium of possible energy related technology developments and areas of current research and development activity.

R. Uhlig, D. Forbes, J.H. Bair, *The Office of the Future*, North Holland Press, Amsterdam, 1979

Produced out of the Bell Northern Research Labs, this book reviews all aspects of the "office of the future" including the technology systems, the role of communications and the anticipated impacts on individuals and organizations. Though clearly reflecting its joint authorship, it is one of the clearest and most comprehensive as well as authoritative books available on the subject. It does however fail to anticipate the current proliferation of personal computers in the office and the impact which they are having and will have.

THEME II — CONCERNS ABOUT THE CONSEQUENCES OF CHANGE

Marc Bélanger, *The New Electronic Canada*, Canadian Union of Public Employees, *The Facts* (volume 5, number 7, September, 1983)

This lively document is a special issue of CUPE's regular membership magazine. It reviews the new information and communications technologies and examines from the labour perspective their impacts on health and safety, employment and society as a whole. The indications are ominous according to this report.

Linda Blais, *Les impacts de la technologie de l'information*, Ministère des Communications, Québec, 1983

This document provides a brief overview of the anticipated impacts of the new technologies paying considerable attention to the positive impacts in such areas as the professions, energy use and cultural development. In addition the study identifies a range of negative impacts especially from the perspective of Francophones and Québécois.

P. Bonnelli, A. Fillian, *L'Impact de la micro-électronique*, Commissariate Général du Plan, Paris, 1981

This report to the President of France reviews the new micro-electronic technologies and the related industrial developments. It goes on to discuss its application in consumer and other areas, its impact on energy use and on productivity and employment. It concludes with recommendations for a series of initiatives to be taken to respond to the challenges presented.

Michael Brown, B. Billingsley, R. Rhumai, *Privacy and Personal Data Protection*, Research Publication #15, Commission on Freedom of Information and Individual Privacy (Williams Commission), Government of Ontario, 1980

This volume and certain of the other volumes of the Williams Commission provide a very useful background to the privacy issues which are likely to arise as a result of the widespread computerization and inter-connection of personal data bases. This report examines in detail current Ontario government practices and provides a series of useful case studies on personal data keeping and use in a number of areas.

Michel Clermont, *Informatique et Emploi*, Ministère des Communications, Québec, 1983

This study reviews the anticipated impacts of information technologies on employment and employees in Quebec including the organization of work, the place and duration of work, health and safety and so on and makes recommendations concerning government actions in response to these impacts. This report draws on the same limited information base as the other reports in the field.

Kai Elgie (ed.) *Proceedings of the Forum on the Social Impacts of Computerisation*, Waterloo Public Interest Research Group, Waterloo (Ont.), 1982

This conference brought together some of Canada's leading observers on the social impacts of the new technologies. Among the subjects discussed were Telidon, computer aided learning, employment, women, privacy, computers and the Third World and copyright. The proceedings give a useful overview of current thinking on the negative social impacts of the new technologies but on occasion touch on the more positive social uses.

M. Larochelle, *Information et utilisation du français*, Ministère des Communications, Québec, 1983

S. Goulet, *Les répercussions culturelles de l'information au Québec*, dossiers du Conseil de la langue française #12, Québec, 1982

These two studies examine the impact of informatics and "informatisation" on the culture of Quebec and on the use of French. The Goulet document examines how the process of integrating computers into daily use will affect the nature of culture. Larochelle examines at an empirical level the relatively weak situation of the French language in the rapidly expanding area of computerized information bases and the threat this poses to the culture and sovereignty of Quebec.

New Views: Computers and New Media — Anxiety and Hopes, Commission on New Information Technology, Stockholm, 1979

This is a condensed version of a longer report by the commission which in turn summarizes a number of more detailed reports dealing with new media (specifically videotex and teletext). The report reviews existing media use in Sweden and examines the role that the new media may play in that context. There is a discussion of the issues presented by the technology (similar to those of concern in Canada) and also a discussion of the legal issues which are developing.

Richard Patent, *A l'orée de la télématique: les équipements de communications des ménages québécois*, Ministère des Communications, Québec, 1982

This very interesting study reviews the communication technologies as they currently impact on the household, and discusses the future household based systems and services and their markets. It then goes on to examine the impacts which these systems and services may have on households, on individuals and on society as a whole. The study integrates a wide range of information pertinent to the analysis of the household markets and impacts of new technologies in Quebec and elsewhere.

Stephan G. Peitchinis, *The Employment Implications of Computers and Telecommunications Technology*, Department of Communications, Ottawa, 1981

This is one of a series of reports prepared by Professor Peitchinis of the University of Calgary on technology and employment. These studies involved both broader national surveys and in depth examinations of particular firms and industries and found that overall, while there had been considerable job change the "employment effects of computers and computer-related electronic systems have been generally positive."

Heather Menzies, *Women and The Chip: Case Studies of the Effects of Information on Employment in Canada*, Institute for Research on Public Policy, Montreal, 1981

Proceedings of a Conference on the Impact of Micro-Electronic Technology on the Work Environment, Labour Canada, Ottawa, 1981

Labour Canada Task Force on Micro-Electronics and Employment, *In the Chips: Opportunities, People, Partnerships*, Labour Canada, Ottawa, 1982

These three publications indicate the significance and concern which is being assigned to the employment and working environmental implications of micro-electronics: especially women's clerical employment. The three reports argue that the impact will be highly significant and that appropriate measures should be taken to plan for and alleviate the problems which will arise. In the Labour Canada reports, attention is also given to the quality of the working environment which it is believed is being negatively affected by micro-electronic based systems.

Ted Nelson, *The Home Computer Revolution*, Ted Nelson, The Distributors, South Bend, Indiana, 1977

This is one of the first of the books describing how the micro computer can become a home and personal-use computer, transforming the way in which daily life as well as daily work are conducted. An optimistic vision is presented where information is immediately and freely accessible and where this information is useful to individuals in transforming their ways of life and liberating them from centralized institutions and centralized workplaces.

June Rada, *The Impact of Micro-Electronics*, International Labour Organization, Geneva, 1980

Diane Werneke, *Micro-Electronics and Office Jobs: The Impact of the Chip on Women's Employment*, International Labour Organization, Geneva, 1983

These two complementary studies examine on a global scale how micro-electronics is affecting both industrial and employment structures. The overall picture is one of rapid and widespread change and with the threat of significant unemployment especially in clerical and white collar occupations in the short term. Both studies, especially in the latter, draw to some degree on Canadian materials and thus provide a useful context for examining Canadian concerns in a global context.

THEME III — PUTTING THE TECHNOLOGY IN PLACE

A l'heure des biotechnologies: programme d'intervention pour le développement de la recherche en biotechnologie au Québec. Phase I: 1983-87, Secrétariat à la Science et à la Technologie (Gouvernement du Québec), Québec, 1982

This report presents an analysis of the current state of biotechnology and opportunities for development in the area in Quebec. A number of recommendations in support of biotechnology development are made with respect to human resources, technology transfer, financing and the role of the Quebec government in the process.

Advisory Committee on Artificial Intelligence for the Ministry of Education and Sciences (Netherlands) *Artificial Intelligence in the Netherlands*, 1983

A Programme for Advanced Information Technology: The Report *of the Alvey Committee*, Department of Industry, HMSO London, 1982

Commission of the European Communities, *Communication from the Commission to the Council on Laying the Foundation for a European Strategic Programme of Research and Development in Information Technology*, Brussels, 1982

Proceedings of the International Conference on Fifth Generation Computer Systems, Japan Information Processing Development Center, Tokyo, 1981

These reports and a large number of others are concerned with developing strategic plans for their respective jurisdictions in the light of the on-rushing information technologies and specifically artificial intelligence related technologies. Having been brought to widespread attention by the Japanese Fifth Generation project announced at the 1981 conference, country after country has quickly convened high level committees to develop appropriate responses. The above reports provide an indication of the seriousness with which these developments are being taken. Each gives country specific recommendations for development.

Bâtir l'avenir: les communications au Québec, (Recherche et Développement: Bilan et Perspectives), Ministère de Communications, Québec, 1982

This is the report of a working group struck by the Quebec Ministry of Communications in association with the Ministry of State for Scientific and Cultural Development to review the current state of research and development in communications in Quebec. The report reviews the current situation both outside and inside Quebec and concludes that intervention by the Government of Quebec is required because of the importance of the sector and because of the weaknesses in current activities.

Economic Council of Canada, *The Bottom Line: Technology, Trade and Income Growth*, Ottawa, 1983

This is a detailed examination of technology within the context of the Canadian economy and Canadian economic growth. The study identifies the importance of technology adaptation and diffusion in the Canadian context and examines current government assistance programmes in support of technical advance. It concludes with an examination of Canadian trade policy and its impact on the economy. Recommendations as to change in government policy concerning technology support and trade are presented. This report is in certain respects a restatement of the position taken by the Science Council in its report, *Forging the Links: A Technology Policy for Canada* (1979).

Edward Feigenbaum and P. McCorduck, *The Fifth Generation* and *Japan's Computer Challenge to the World*, Addison-Wesley Publishing Co., Reading, Mass., 1983

This book is an American "call to arms" on the style of the "Nora-Minc" Report or Servan-Schreiber's warnings about *le défi américain. Written by one of the leading experts in artificial intelligence and the foremost non-academic chronicler of the subject, The Fifth Generation* examines Japan's plan to build a computer that is capable of a variety of functions which we currently associate with thought. This project, announced in 1981, focusses Japan's national energies into the building of the world's most intelligent (and most accessible to the layman) machine. The book makes several recommendations concerning appropriate U.S. responses.

Feigenbaum and McCorduck see this project as a significant challenge to U.S. computer and, ultimately, industrial and social supremacy and they challenge the various groups in the U.S., both industrial and governmental, to respond.

Le virage technologique, Gouvernement du Québec, Québec, 1982

This document is an overall examination and plan of action by the Quebec government for sustained economic advance, and technological development. The development of technology based enterprises are seen as a key component of this direction and a program of action to achieve this is presented.

Les conférences socio-économiques du Québec, *Le Québec et les communications: Un futur simple*, Ministère des Communications, Québec, 1983

This is a comprehensive look at the present and future of communications in Quebec and was developed as background for a major conference to be held in October, 1983. The report raises questions concerning the future role of government in strengthening communications services and industries within the overall context of Quebec's economic, social and industrial strategies.

Simon Nora and Alain Minc, *The Computerization of Society: A Report to the President of France*, MIT Press, Cambridge, Mass., 1980 also *L'informatisation de la société*: un rapport au président de la République, la documentation française, Paris, 1978

This report gained considerable attention both in France and internationally in its call for a national strategy to respond to the new opportunities and risks presented by telematique (telecommunications and information processing). Interestingly they note that Canada was the first to understand that something novel might result from the combination of the two.

The report makes a number of observations concerning micro-electronics and the risks to various employment sectors, to national sovereignty, and to various industrial areas novel at the time but which have by now become commonplace.

Robert Reich, *The Next American Frontier*, Times Books, New York, 1983

This book examines the reasons for the current American industrial decline (deindustrialization) and presents a series of strategies for industrial renewal. The central theme of these strategies is the need for a national (and Japanese style) "industrial strategy" based on a consensus of opinion among labour, industry and government.

Science Council of Canada, *Planning Now For an Information Society: Tomorrow is Too Late*, (Report #33) Ottawa, 1982.

This report from the Science Council reviews the new technologies and their potential impact on Canada and Canadians. It argues for policy direction on future new developments and makes recommendations concerning the necessary response by government to the challenges being posed.

Task Force on Biotechnology, *Biotechnology: A Development Plan for Canada*, Ministry of State for Science and Technology, Ottawa, 1981

This document reviews the current state of knowledge and activity in the area of biotechnology in Canada and abroad and presents a plan for the stimulation of an effective Canadian presence in the area. The objective of the plan is to create a climate for the development of a variety of biotechnology-based Canadian industries.

Un projet collectif: énoncé d'orientations et plan d'action pour la mise en œuvre d'une politique québécoise de la recherche scientifique, Gouvernement du Québec, Québec, 1980

In this report the objectives of, and a plan for, the development of scientific research in Quebec are outlined. Among the areas observed are the proposed "collective" and "democratic" objectives of Quebec scientific research, the development of appropriate scientific manpower, the management strategy for the stimulation of science, research, and financing and the development of appropriate policy mechanisms in the scientific area.

Working Group on Industrial Policies, *Multinationals and Industrial Strategy*, Science Council of Canada, Ottawa, 1980

This is a report examining one of the possible strategies in support of innovation and technological development in Canadian industry. The strategy of four companies with world product mandating is reviewed and conclusions and policy implications are drawn from these. The opportunities and limitations within the specific context of Canadian industry are examined.

Z. Zeman, *Men With the Yen*, Occasional Paper #15, The Institute for Research in Public Policy, Montreal, 1980

Japan is examined from a Canadian perspective in this document. The role of Japan globally has clearly changed and is changing further — from an exporter of low quality goods, to an exporter of high quality adaptations of the technologies of others, to a major thrust to become a major technological innovator and the world's number one economy. The strengths and weaknesses of contemporary Japan are examined and Canadian policy options for responding to, and developing with, the Japanese initiatives are discussed.

Dirk de Vos, *Governments and Microelectronics*, Science Council of Canada, Ottawa, 1983

This very useful document reviews the current experience and practice of European governments with respect to promoting investment and innovation in microelectronics and its applications. Among the countries examined are the United Kingdom, France, West Germany, Sweden and the Netherlands. While no conclusions are drawn, the report notes that "even quite small economies have had a head start of at least four to five years with the kinds of studies and exhortations about monitoring technologies that began to surface in Canada only in 1982".

THEME IV — ADJUSTING TO CHANGE

James W. Botkin, M. Elmandjra, M. Malitza, *No Limits to Learning: Bridging the Human Gap* (A Report to the Club of Rome) Pergamon, 1979

This book places learning and especially "innovative learning" as the central means for individuals to adjust to change and for individuals especially in the developing world to promote and maintain effective change. Innovative learning is described and contrasted with other types of learning. How effective learning can lead to a resolution of world problems is discussed.

M. Brossard et N. Durany, *Le plein emploi à l'aube de la nouvelle révolution industrielle*, Université de Montréal: l'École de relations industrielles, Montréal, 1981

This volume contains the proceedings of a conference examining the employment impacts of microelectronics. It is particularly useful in that it brings together comment, analysis and discussion from academics, public servants, industrialists and labour to discuss the problems and mechanisms of adjusting to microelectronic-induced change in the working environment.

R. Dorion, *Adapting to a Changing World: A Reader on Quality of Working Life*, Labour Canada, Ottawa, 1981

Although not specifically concerned with new technologies this collection of essays provides an introduction to quality of working life approaches to the management of industrial and organizational change. These possibilities are particularly important in the light of the extent of change which is taking place and the problems of adjustment which are arising.

Fred Hirsch, *Social Limits to Growth*, Harvard University Press, Cambridge, Mass., 1976

This book examines the central theme that there are natural limits on the distribution of social goods and services. Ever advancing expectations concerning wealth and the good life eventually run up agianst barriers where the gain of one inevitably means loss to another or even to all. As the state, rather than the market, becomes increasingly responsible for the distribution of these goods the legitimacy of the allocation mechanisms and thus of the state is called into question.

R.F. Laidlaw, *Co-operatives in the Year 2000*, Co-operative Union of Canada, Ottawa, 1980

This report by one of Canada's leaders in the world co-operative movement examines the future of co-operatives in the context of economic and social difficulty and technology change. Co-operatives provide one option for promoting and managing change both in the marketplace and in the developing world, it is suggested.

Yoneji Masuda, *The Information Society as Post-Industrial Society*, Institute for the Information Society, Tokyo, 1981

This very influential book was written by one of Japan's leading thinkers in the area of information economics and social futures. This book outlines current developments towards an information society and indicates what shape that society is likely to take when it has fully emerged. The book is especially interesting in giving a Japanese perspective on the problems and opportunities presented by the information society and a blueprint for its emergence by one of Japan's leading architects of this development.

Policy Options, The Institute for Research in Public Policy, Montreal

This magazine, currently appearing six times yearly, regularly presents informed and useful discussions of Canadian issues and the policy options which are available to respond to these. Recent issues have included discussions on stimulating technology (Jan./Feb. 1983), shorter working hours (May/June 1983), workers' cooperatives (May/June 1983), training, planning and so on.

Jean-Jacques Servan-Schreiber, *The World Challenge*, Simon and Schuster, New York, 1980

This book presents the global challenge of microelectronics especially as it opens up possibilities for positively addressing the problems of the third world. The book provides a readable overview of world developments with respect to microelectronics and identifies the dangers which these developments pose. The book so influenced the then President of France that a world centre for the study of microelectronic applications was established in Paris to pursue microelectronic applications in the areas of Third World development and education, among others.

Roxanne Hiltz Starr and Murray Turoff, *The Network Nation: Human Communication Via Computer*, Addison Wesley Publishing Co., Reading, Mass., 1978

"During the next two decades, inexpensive computer power and communications links will facilitate the emergence of vast communication-information networks. The network nation is a society in which telecommunications via computer networks has shrunk time and distance barriers among people, and between people and information, to near zero. So that the reader may understand the nature and consequences of the emerging network nation, the authors review the history of the technological innovations that have made it possible, discuss what is known about the social and psychological impacts of this new form of communication, look at the potential application to a wide range of societal processes, and review the present and future technical and policy issues related to such applications" (from the inside rear cover).

Social Planning Council of Ottawa-Carleton, *Techno-Peasant Survival: A Workshop on High Technology Planning and Job Access for Low Income Groups*, Ottawa, 1982

In November 1982 the Social Planning Council of Ottawa-Carleton organized a workshop where a report on access by the poor to high technology employment was presented. This workshop identified a number of ways in which hi-tech employment by disadvantaged individuals could be promoted.

K. Valaskakis, *The Information Society: The Issues and the Choices*, Gamma: Université de Montréal/McGill University, Montreal, 1979

This is the integrating report of a large project undertaken by the futurist Gamma Group to examine the various aspects of Canada as an information society. It provides a useful integrated perspective on some of the issues and options which the new technologies thrust upon Canada and places Canada in the context of the larger developments taking place internationally.

Vanier Institute of the Family, *The Future of Work: A Contribution to the Public Debate on Canada's Future*, VIF, Ottawa, 1981

This is the edited proceedings of an international workshop on the future of work. The papers presented examine not only adjustment to change but also the fundamental definitions and meaning of work and suggests that adjustment is taking place not only through formal but also through informal and personal channels.

Work For Tommorrow: Employment Opportunities for the '80s. House of Commons (Parliamentary Task Force on Employment Opportunities for the '80s — The Allmand Committee) n.d.

This report examines employment and training practices within the context of changing manpower and skill requirements. The report discusses the various elements of the skilled manpower preparation system and makes a series of recommendations based on a perception of a mismatch between labour and skill supply and demand and the particular problems of specific groups.

SELECTED VIDEOGRAPHY

Canada

The Electronic Web — Quarterly Reports Series

56:50 min. col., 1981, videotape
Producer: Ken Hazzam
Distributor: CBC Enterprise, Toronto
Rent: $75
Purchase: $400
Content: The film looks at the dark side of the information revolution and the threat to the privacy of the individuals in the age of computers.

Switching On — Your Life in the Electronic Age

57:05 min. col., 1981, videotape
Producer: Wendy O'Flaherty
Distributor: CBC Enterprise, Toronto
Rent: $75
Purchase: $400
Content: *Switching On* explores the incredible advances in computer technology realized by the silicon chip and reaches two significant conclusions:
1) the reduction in human toil will lead to a vast decrease in the number of jobs; and
2) if work can no longer be the basis for pay a guaranteed annual income may be necessary.

Japan

The Super Achievers — Nature of Things Series

57:20 min. col., 1982, videotape and film
Producer: James Murray
Distributor: CBC Enterprise, Toronto
Rent: $75
Purchase: $400
Content: Japan has combined hard work and clever innovation with an uncompromising scrutiny of business and industry to rise from near obscurity to a major industrial power.

Les robots

19:53 min. col., 1981, 16 mm
Producer: CBC
Distributor: National Film Board
Rent: free (public libraries and NFB libraries)
Purchase: $375
Content: Are robots beneficial or harmful to man? A look at the invasion of robots in our lives.

Downside Adjustments

60 min. col., 1983, 16 mm
Produced by: Mary Jane Gomes and Emile Kolompar
Distributor: DEC, (416) 964-6901
Rent: $90 (community) $95 (institution)
Purchase: price not available yet (approx. $1300)
Content: The film looks at the effects of new technology on the auto industry and how it affects lives of working people in the auto industry in Windsor.

Fast Forward – A series on the new technologies and their implications

30 min. each, col., 1980, video
Producer: Ontario Educational Communications Authority
Distributor: TVOntario
Rent: free
Purchase: price not available
Titles: The Micro-electronic Revolution
Humanizing the Technology
Bio-engineering 1
The Information Flow
New Perspectives
Computer Simulation
Memory and Storage
Electricity/Energy
Transportation
Space
Business of Information
Security
Medicine
About Computers
State of the Arts
Implications

Computer: Computerized Supermarkets

23 min. col., 1979, vtr.
Produced by: University of Manitoba
Distributor: Thomas Howe Associates, (604) 687-4215

Rent: $25
Purchase: $250
Content: This program visits a recently automated supermarket. The Universal Product Code (UPC) and the equipment needed to utilize the system are explored. Potential problems with such a system as seen by the Consumers Association are also presented.

England

BBC Horizon Series
Goodbye Gutenberg

80 min. col., 1980, 16 mm
Producer: Edward Goldwyn
Distributor: BBC Toronto
Rent: educational use $90
non-educational use $125
Purchase: educational use $1125
non-educational use $1160
Content: As more and more words fly free of the printed page and are processed and stored in computers, Horizon looks at existing examples of the new information technology and its effect on democracy, national boundaries, language, bureaucracy and privacy. This programme also examines some of the more far-reaching and subtle effects of the new information age, the cultural changes that may lie ahead and what the haze of electronic pulses will do to our way of life.

Halfway to 1984

50 min. col., 1976, 16 mm
Producer: BBC
Distributor: BBC Toronto
Rent: educational use $65
non-educational use $100
Purchase: educational use $925
non-educational use $950
Content: The film is an examination of the issues raised by recent developments in computer technology which have made mass surveillance and its political misuse a practical possibility.

Now the Chips Are Down

50 min. col., 1978, 16 mm
Producer: BBC
Distributor: BBC Toronto
Rent: educational use $65
non-educational use $100
Purchase: educational use $925
non-educational use $950
Content: A microprocessor is science fiction fantasy in a tiny chip of silicon. Cheap to produce, it will function like a big computer, making possible a machine that can read aloud, a driverless tractor, a production line without humans, a warehouse that needs no staff. Robots controlled by microprocessors can not only do any welding, cutting or assembly jobs — they can also "learn" human skills.

U.S.A.

The Ultimate Machine

30 min. col., 1971, 16 mm
Producer: Time-Life Films
Distributor: Marlin Motion Pictures Ltd.
Rent: $50
Purchase: $644
Content: The film examines the development and use of the computer. It shows an automated oil refinery where computers control production, a child learning from a classroom computer, and scientists building a manlike robot.

The Mind Machines

57 min col., 1978, 16 mm
Producer: WGBH — T.V./Time-Life Films
Distributor: Marlin Motion Pictures Ltd.
Rent: $66
Purchase: $1007
Content: Examines and interviews scientists working and researching Artificial Intelligence, a branch of computer science. Predictions of machines more intelligent than their creators stirs lively discussions. Computers are shown playing and winning chess, diagnosing medical problems, controlling robots used in space science and operating assembly line functions.

Computers, Spies and Private Lives

59 min. col., 1981, 16 mm
Producer: Time-Life Films
Distributor: Marlin Motion Pictures Ltd.
Rent: $66
Purchase: $1073

Content: This film reveals how computers, routinely gathering information on our finances, politics, tastes and habits, may prove a threat to our individual privacy. Discussed in detail are nationwide computer banks, which store this information, and computer thieves, who can break computer codes to obtain data that may endanger both domestic and international financial institutions. Also examined are telecomputers, which may replace direct mail, and "smar cards", which look like ordinary credit cards but which contain a computer code known only to the owner and thought to be unbreakable.

Michael Gurstein
Socioscope Inc.